INSTRUCTIONS FOR THE MANAGEMENT OF GAS WORKS.

INSTRUCTIONS

FOR THE

MANAGEMENT OF GAS WORKS.

INSTRUCTIONS

FOR THE

MANAGEMENT OF GAS WORKS.

BY

W. C. HOLMES & Co.,

ENGINEERS AND CONTRACTORS FOR GAS WORKS, WHITESTONE IRONWORKS,
HUDDERSFIELD.

LONDON:

E. & F. N. SPON, 48, CHARING CROSS.

NEW YORK: 446, BROOME STREET.

1874.

INTRODUCTION.

THE object of the following pages is to supply a want which has long been felt, namely, a few general instructions for managing or conducting private or small public gas works, so as to be able to realize the best and most economical results. To works for the supply of large towns, these instructions do not, as a matter of course, apply, as they have, in general, the means of employing well-skilled engineering assistance. It is, however, altogether different with works on a small scale, more especially those for supplying villages and small towns, the directors of which, from the limited funds at their command, are necessarily compelled to economise those funds as much as possible; in many instances, one man only is required to perform the whole of the operations necessary, some respectable person in the locality being engaged to keep the books and collect the gas accounts at a small salary; in other cases, a manager, with two or three assistants, and a collector are employed. It is especially for the benefit and guidance of such works, and of private works also, that these "Instructions" have been arranged in their present form, though it will perhaps be found that in some instances, information may be extracted from them which may be of service in the management of works on a much larger scale.

It is desirable to impress on the minds of both the directors and the officials charged with the control and management of gas works, that it is of the first importance that the books

be kept in the plainest and simplest manner possible, but at the same time, so detailed and arranged that the results of the management and the economical bearings of such management may be seen and understood at any time by even those who are comparatively unaccustomed to matters of that description. For this purpose, rules and forms are given, which, if adopted, should be strictly adhered to, both by the manager and collector.

With regard to the forms, it will be seen that some of them are not intended for books, but as loose sheets, to be filled up periodically for examination and revision by any independent person whom the directors might think proper to appoint. It would be of considerable advantage to the company if the directors were to arrange to send these forms regularly to some well-qualified gas engineer for inspection, and to provide that he should examine personally and report on the works to them, say twice a year or oftener, if necessary. With the knowledge thus acquired of the actual working of the concern, and the conclusions to which he would consequently come, he would be enabled to point out at once any mismanagement, or to recommend any necessary alterations or additions. By so doing, his fees or charges would be amply repaid by the saving effected.

The control of any gas works, whether large or small, should be exercised with the same regularity and precision as that of a cotton factory or other well-regulated establishment, whether such control is in the hands of the director, engineer, or manager, or these combined. If a satisfactory result to the proprietors or shareholders is desired, laxity of management and of supervision, or want of careful attention on the part of those whose duty it is to see to such matters, will infallibly lead to unsatisfactory and often disastrous consequences. As will be seen on perusal, the instructions here given are

W. C. Holmes & Co.,

intended to apply to works where coal only is used as the gas-producing material. Instructions for the conduct of works wherein the gas is made from oil, petroleum, peat, wood, resin, or other materials, will be given in a work, which will shortly be brought before the notice of the public, on gas-lighting generally, in all its branches.

It is believed that no work or manual has been hitherto published, having for its professed object the collection of such practical information as may be of service both to the managers of gas works and to the directors and others who may be interested in the subject. Much of the information herein given, more especially that relating to the analysis and chemistry of gas, is due to such authorities as Dr. Frankland, Mr. L. Thompson, Mr. Clegg, *The Journal of Gas-Lighting, &c.*

These "Instructions for the Management of Gas Works" are not intended to apply to the general construction and details of arrangement of the plant and apparatus. It will be readily understood, however, that the financial success of any works, great or small, is very considerably influenced by the manner in which they have been first arranged and erected; the only safe-guard against both annoyance and loss in this respect, is to engage the services of a well-qualified gas engineer, accustomed to the erection of works of the magnitude required, and whose practical experience will enable him to advise on and erect the plant and apparatus best suited to the requirements of the place to be lighted.

Huddersfield and London.

CONTENTS.

INSTRUCTIONS

FOR THE

MANAGEMENT OF GAS WORKS.

COAL.

ce of Coal.

THE choice of coal for the production of gas depends, in a great measure, on circumstances—as locality and economy. Where economy is the primary object, the coals most easily and cheaply obtained should be tried, and the best, or the one yielding the largest quantity of gas per ton, combined with the best quality of both gas and coke, should be then used. Where economy is a secondary object, cannel coal produces the richest and most brilliant gas; it is an improvement, however, to mix a certain proportion, say 50 per cent., of ordinary Newcastle or other equally good common gas coal with it, in order to produce a more permanent quality of gas, as the greater the amount of olefiant gas which it contains, the greater the proportion to which it is affected by temperature, and by contact with water.

orption of by contact h Water.

It has been found by Dr. Torrey, that one volume of water absorbs of

	At 32° Fahr.	At 59° Fahr.	At 68° Fahr.
Hydrogen	0·01930	0·01930	0·01930
Carbonic Oxide	0·02287	0·02432	0·02312
Light Carburetted Hydrogen	0·05449	0·03909	0·03499
Olefiant Gas	0·25630	0·16150	0·01488

From which it appears that water, at 59° Fahr., absorbs—

8·37 times more olefiant gas than hydrogen			
6·64 times	ditto	ditto	carbonic oxide
4·13 times	ditto	ditto	light carburetted hydrogen

and at lower temperatures the absorption is greater in proportion; an increase of pressure has, also, the same effect.

Coke.

In addition to this, the coke produced from a mixture of cannel and common coal, is more valuable or useful according to the proportions; the coke from cannel coal being of little or no value as fuel. The greater also, the amount of volatile matter contained in the coal, the higher must be the heat of the retorts for its conversion into gas.

Analysis of Coal.

Specific Gravity.

The following method of analysing various descriptions of coal, in order to select those best suited for the purpose of making gas, is proposed by Mr. L. Thompson:—To determine the specific gravity of any particular sample, it is convenient to employ a piece of coal weighing about 500 grains; this is attached by a hair or slender thread to one pan of a balance, the other containing the weight requisite to counterpoise it; if we now permit the suspended piece of coal to dip into a vessel of water placed beneath, it will float on the surface of the water, until sufficient weights are added to the pan from which it hangs to enable it to sink slowly through the fluid. If, after removing the smallest of these weights, the coal rises again to the surface, we know that the proper weight lies between the two thus found. Suppose, for example, that the coal weighed at first 540 grains, but has required 433 grains to sink it, whilst with 432 grains it swims. then the true weight may be taken at 432½ grains, and the original weight, divided by this weight, gives the specific gravity of the coal, which, in the instance chosen, would be 1·2485, assuming water as unity.

Proportions of Volatile Matter and Coke.

The next step is to determine the amount of volatile matter and coke which the coal contains. For this purpose a small iron crucible, provided with a cover perforated by a hole, may be employed. Having carefully weighed out 100 grains of the coal, it must be introduced into this crucible, and the cover being applied, the whole is subjected to a red heat, until all evolution of inflammable gas has ceased to issue through the aperture in the cover; when this is seen to be the case, the crucible must be removed from the fire and suffered to cool, after which the coke may be taken out and weighed. The loss or difference in weight is the quantity of volatile ingredients in the coal. It is

better to make three successive experiments on each coal, and to take the average ; and these experiments should furnish results which do not differ more than one grain from each other.

›ortion of or Incom- ible Matter.

Having thus ascertained the proportions of coke and volatile matters, the coke must be placed in a muffle heated red-hot, and through which a current of air passes slowly ; here the carbon is consumed and carried away, leaving the incombustible residue or ash behind, which must then be carefully weighed. If a small shallow vessel, made by turning up the sides of a piece of platinum foil, has been used to contain the coke, this is easily withdrawn at the end of the operation, and being transferred to the balance, we are enabled to weigh the whole without the risk of loss.

ount of phur in the ıl.

To ascertain the quantity of sulphur existing in the coal, reduce 100 grains of the coal to a fine powder, with which must be mixed about 30 grains of pure carbonate of soda, also in fine powder. The mixture being now placed in a small iron ladle, similar to those used in melting lead, this is next placed over a clear fire, so as to admit of the free ingress of air, by which the bituminous and carbonaceous ingredients of the coal are gradually burnt off, whilst the sulphur combines with the metallic portion of the soda, to form sulphuret of sodium. By retaining this latter a sufficient time over the fire, it would ultimately be converted into sulphate of soda ; but it is better to expedite this process, and this is easily effected by sprinkling the mass whilst red-hot with powdered nitrate of potash, so long as any deflagration occurs. When this ceases altogether, the heat should be raised for a few minutes, after which the ladle may be removed from the fire and suffered to cool. The soluble contents of the ladle are now to be extracted by boiling water, and the solution filtered. The filtered liquid being then supersaturated with pure nitric acid, is next treated with an excess of a solution of nitrate of baryta, by which a precipitate is formed, and this precipitate, carefully collected on a counterpoised filter and well washed with boiling distilled water, may now be dried and weighed in the usual manner. Every 117 grains indicate 16

grains of sulphur, consequently, we thus determine the amount existing in 100 grains of the coal.

Amount of Sulphur in the Volatile Matter.

To find the quantity which passes off with the volatile matters, nothing more is necessary than to heat 100 grains of the coal in an iron crucible, as recommended for the determination of the volatile ingredients. The coke left after this process is then to be powdered, mixed with carbonate of soda, and treated exactly as indicated above with respect to the coal itself, by which its content of sulphur will also be determined, when, it is needless to say, that the difference represents the amount carried off in a volatile state, as nearly as chemical analysis can approach perfection. To the gas manufacturer, this is a question of great importance; for, although it frequently happens that the sulphur exists in coal as bisulphuret of iron, in which case it is equally divided between the fixed and volatile matters, yet there are some coals, the Boghead and Capeldrae for instance, in which nearly the whole of the sulphur is expelled, and goes away with the gaseous products. This is precisely one of the questions which practical men should, therefore, invariably determine for themselves, as it will not unfrequently enable them to account for much seeming mystery and inequality in the action of the purifiers.

Presence of Lime in Coal.

In some of the bituminous coals, an appreciable quantity of carbonate of lime is found spreading itself in thin layers between the fissures of the coal; this substance has a remarkable effect in retaining the sulphur of the coal in the coke. It may, indeed, be looked upon as lime, and in this respect produces all the good effects which that substance is capable of performing in a purifier. This carbonate of lime, by the action of the impure coal gas, resolves itself into sulphuret of calcium, whilst its carbonic acid most probably becomes carbonic oxide. To the coke-maker therefore, the presence of carbonate of lime in coal should be an objection, but the contrary as regards the gas-maker.

The following Table gives an analysis of the principal coals used for gas-making :—

ANALYSES OF VARIOUS COALS.

NAME OF COAL.	Specific Gravity.	Volatile Matter per cent.	Coke per cent.	Ash per cent.	Sulphur in Coal.	Sulphur in Coke.	Sulphur in Volatile Matter.	Ash in Coke per cent.
CANNEL COALS.								
Arniston	1·1967	45·5	54·5	4·18	1·70	0·95	0·75	7·66
Boghead	1·2210	68·4	31·6	22·8	0·53	0·08	0·45	70·25
Capeldrae	1·2275	54·5	45·5	10·5	0·65	0·20	0·45	23·07
Kirkness	1·2080	60·0	40·0	13·5	1·40	0·58	0·82	33·70
Knightswood	...	48·5	51·5	2·4	1·10	0·61	0·49	4·66
Lesmahago	1·2220	49·6	50·4	9·1	2·23	1·14	1·09	18·05
Lochgelly	1·3200	33·5	66·5	13·1	0·75	0·25	0·50	29·70
Old Wemyss	1·3256	52·5	47·5	15·1	1·30	0·60	0·70	31·78
Wigan	1·2710	37·0	63·0	3·0	1·25	0·60	0·65	4·76
Ramsay's Newcastle ...	1·2900	36·8	63·2	6·6	1·75	0·94	0·81	10·44
Band of Cannel in Leverson's Wallsend ...	1·3200	30·8	69·2	9·35	1·00	0·50	0·50	13·67
Band of Cannel in Pelton Main Coal ...	1·3200	31·5	68·5	9·4	0·95	0·49	0·46	13·70
Band of Cannel in Washington Coal ...	1·3260	27·4	72·6	9·37	1·10	0·56	0·54	12·90
Staffordshire	1·2200	50·0	50·0	2·9	1·30	0·52	0·78	5·80
New Brunswick ...	1·0980	66·3	33·71	0·6	0·07	none	0·07	1·78
BITUMINOUS COALS.								
Harecastle, Cheshire ...	1·2300	31·5	68·5	5·0	2·10	1·10	1·00	7·30
Cumberland No. 1 ...	1·2940	25·5	74·5	2·1	1·30	0·70	0·60	2·80
Do. No. 2 ...	1·2750	25·6	74·4	1·4	1·10	0·60	0·50	1·90
Do. No. 3 ...	1·2900	30·9	69·1	4·0	1·70	0·80	0·90	5·80
Staveley	1·2750	40·9	59·1	2·7	1·20	0·80	0·40	4·57
Coalpit Heath, Gloucestershire	1·3700	30·1	69·9	5·8	4·10	2·20	1·90	8·30
Whitecroft, near Lydney, Gloucestershire	1·4010	34·3	65·7	11·1	3·10	1·90	1·20	16·80
Arley, Lancashire ...	1·2700	33·7	66·3	3·6	1·20	0·60	0·60	4·80
St. Helens „ ...	1·2850	37·2	62·8	1·2	1·10	0·54	0·56	1·91
Blenkinsopp	1·2980	38·0	62·0	5·1	1·60	0·80	0·80	8·20
Dean's Primrose ...	1·2610	29·25	70·75	2·4	1·40	0·71	0·69	3·40
Garesfield (Butes') ...	1·2900	28·3	71·7	3·2	0·90	0·40	0·50	4·40
„ (Cowans') ...	1·2590	29·4	70·6	0·95	0·85	0·40	0·45	1·30

Huddersfield and London.

ANALYSES OF VARIOUS COALS—*continued.*

NAME OF COAL.	Specific Gravity.	Volatile Matter per cent.	Coke per cent.	Ash per cent.	Sulphur in Coal.	Sulphur in Coke.	Sulphur in Volatile Matter.	Ash in Coke per cent.
BITUMINOUS COALS.								
Gosforth	1·2600	35·0	65·0	1·00	1·10	0·50	0·60	1·50
Hastings Hartley ...	1·2780	36·6	63·4	2·00	0·95	0·50	0·45	3·10
West Hartley ...	1·2690	38·8	64·2	4·7	1·10	0·60	0·50	7·30
Leverson's Wallsend...	1·2780	34·9	65·1	4·9	1·30	0·65	0·65	7·52
South Peareth ...	1·2660	27·8	72·2	1·80	1·20	0·60	0·60	2·50
Pelaw Main	1·2710	30·3	69·7	2·60	1·20	0·70	0·50	3·70
Pelton Main	1·2700	28·4	71·6	1·41	1·10	0·62	0·48	1·96
New Pelton	1·2650	30·2	69·8	1·75	1·10	0·56	0·54	2·50
South Tyne	1·3390	36·3	63·7	3·90	2·10	1·10	1·00	6·10
Urpeth	1·2710	28·7	71·3	1·35	1·00	0·60	0·40	1·89
Washington	1·2600	31·25	68·75	2·20	1·30	0·67	0·63	3·20
Nailsea, Somerset ...	1·3120	34·9	65·1	3·00	2·85	1·50	1·35	4·60
Radstock „ ...	1·2750	38·25	61·75	3·50	3·10	1·80	1·30	5·60
Apedale 4 ft., Stafford	1·2670	40·0	60·0	0·75	0·80	0·38	0·42	1·25
Apedale „	1·3070	38·5	61·5	1·90	1·50	0·82	0·68	3·10
Heathern „	1·2800	42·9	57·1	1·75	1·50	0·70	0·80	3·00
Silverdale 10 ft. „	1·3010	34·0	66·0	1·95	1·30	0·70	0·60	2·92
Woodshut's 7 ft., Banbury	1·2910	40·2	59·8	1·22	0·90	0·54	0·36	2·03
Ruabon topyard seam	1·2690	37·5	62·5	2·50	1·40	0·80	0·60	4·00
„ main coal ...	1·2840	41·5	58·5	1·00	1·85	0·45	0·40	1·70
„ yard seam ...	1·2710	34·0	66·0	1·40	1·10	0·60	0·50	2·10
„ Nant seam ...	1·2690	37·9	62·1	1·40	1·10	0·70	0·40	2·20
Rhonda, South Wales	1·2780	22·8	77·2	2·70	2·30	1·20	1·10	3·50
„ low main „	1·2800	23·1	76·9	2·10	2·20	1·10	1·10	2·70
Elsecar Low pit, York	1·2580	37·0	63·0	1·10	1·20	0·63	0·57	1·74
Grigleston Cliff, soft „	1·2550	35·6	64·4	1·60	1·40	0·75	0·65	2·48
Mortomly „	1·2200	37·0	63·0	1·60	1·10	0·60	0·50	2·50
Silkstone No. 1 „	1·2600	34·1	65·9	2·78	1·30	0·80	0·50	4·20
„ 2 „	1·2590	38·0	62·0	2·55	1·10	0·60	0.50	4·10
„ 3 „	1·2620	35·2	64·8	2·80	1·45	0·75	0·70	4·10
Soaphouse pit „	1·2580	35·0	65·0	0·80	0·75	0·40	0·35	1·20
Woodthorpe „	1·3470	33·1	66·9	10·50	1·20	0·70	0·50	16·60
Denain, Valenciennes, France	1·2650	29·9	70·1	6·00	2·40	1·30	1·10	8·57

en, &c.,
al.

It must not, however, be assumed, that the quantity of volatile matter contained in the coal represents the amount capable of conversion into illuminating gas, as due allowance must be made for the oxygen, which passes off, in part combined with hydrogen forming water, and with carbon, forming carbonic acid and carbonic oxide gases—thus, in addition to reducing the amount of volatile matter, acting injuriously by neutralizing or destroying part of the really valuable gas-producing elements of the coal. The amount of water yielded by various coals ranges from 10 to 30 gallons per ton of coal, and therefore, whilst one coal may give a larger percentage of volatile matter than another, the former may be inferior to the latter in illuminating ingredients.

cts of
sture on the
l.

It is almost needless to say, that the coal should be dry before being used, and that it should be stacked under cover. When a quantity of moist coal is thrown into a retort, the outer surface, after undergoing for some time the action of the fire, is converted into coke, and the bisulphuret of iron into protosulphuret of iron, over which latter the steam from the interior of the mass of coal passes, with, of course, the same result as if this protosulphuret of iron were purposely subjected, at a red heat, to the action of the vapour of water; that is to say, the two compounds mutually decompose each other, and give rise to oxide of iron and sulphuretted hydrogen, so that by mismanagement of this kind, the whole of the sulphur contained in bituminous coals may be made to pass off into the gas, and thus double the labour and expense of purification.

The following table will be found to be useful, as showing the quantity of gas to be obtained from various descriptions of coal, its specific gravity, and total weight per ton of coal :—

Huddersfield and London.

QUANTITIES OF GAS DERIVED FROM COAL.

DESCRIPTION OF COAL.	Cubic feet of Gas per ton.	Specific Gravity of Gas.	Weight of Gas in pounds per ton of Coal.	AUTHORITY.
NEWCASTLE COALS.				
English Caking Coals	8000	·420	257	Dr. Fyfe
Newcastle Coals	11648	·475	423	Hedley
Pelaw	11424	·444	389	"
Pelton	11424	·437	382	"
Blenkinsopp	11200	·521	447	"
Newcastle	8500	·412	268	London, 1837
Wallsend...	12000	·490	450	Revolving Web Retort
Pelton	11000	·430	363	L. Thompson
Leverson...	10800	·425	353	"
Washington	10000	·430	330	"
Pelaw	11000	·420	355	"
New Pelton	10500	·415	335	"
Dean's Primrose...	10500	·430	347	"
Garesfield	10500	·398	321	"
Gosforth	10000	·402	308	"
West Hartley	10500	·420	339	"
Hastings' Hartley	10300	·421	333	"
Blenkinsopp	9700	·450	335	"
Berwick & Craister's Wallsend...	12507	·470	449	Clegg
Pelaw Main	12400	·420	399	"
Russell's Wallsend	12000	·418	384	"
Ellison's Main	11200	·416	357	"
Felling Main	11200	·410	351	"
Penrith's Wallsend	11147	·410	350	"
Dean's Primrose...	11120	·410	349	"
Benton Main	10987	·400	337	"
Eden Main	10400	·400	318	"
Heaton Main	10400	·410	326	"
PARROT OR CANNEL COALS.				
Yorkshire Parrot	11500	...	...	Dr. Fyfe
Wigan Cannel	9500	·460 to ·520	357	"
Scotch Parrot	9500	·640	466	"
Ramsay's Newcastle Cannel	9746	·554 to ·580	423	"
Lochgelly Parrot	9123	·567	396	"
Lesmahago Cannel (1st experimt.)	11681	·540	483	A. Wright
Ditto (2nd experiment) ...	9878	·650	492	"
Ramsay's Newcastle Cannel ...	9016	·604	417	"
Ditto ditto	9333	·598	427	Dundee Gas Works
Ditto ditto	9667	·731	541	Dr. Leeson, Dr. Miller, &c.
Lesmahago Cannel	11312	·737	638	Hedley
Welsh Cannel	11424	·737	645	"
Wigan Cannel	11200	·606	520	"
Ditto ditto	9500	·580	422	Liverpool Gas Co.

QUANTITIES OF GAS DERIVED FROM COAL—*continued.*

DESCRIPTION OF COAL.	Cubic feet of Gas per ton.	Specific Gravity of Gas.	Weight of Gas in pounds per ton of Coal.	AUTHORITY.
PARROT OR CANNEL COALS.				
Wemyss Cannel	10976	·670	563	A. Wright
Knightswood Ditto	9720	·590	439	"
Boghead "	15000	·752	866	Chartered Gas Co.
Lesmahago " No. 1 ...	13500	·642	666	"
Ditto " No. 2 ...	13200	·618	627	"
Capeldrae "	14400	·577	638	"
Arniston "	12600	·626	606	"
Ramsay "	10300	·548	433	"
Wemyss "	14300	·580	637	"
Kirkness "	12800	·562	552	"
Wigan " (Ince Hall) ...	11400	·528	461	"
Pelton "	11500	·520	459	Hedley
Leverson "	11600	·523	466	"
Washington "	10500	·500	403	"
Wigan "	14453	·640	708	Clegg
Scotch "	14000	·580	622	"
DERBYSHIRE, WELSH AND OTHER KINDS OF COAL.				
Derbyshire deep Main	9400	·424	308	A. Wright.
Brymbo two-yard	8880	·463	315	"
Powell	10165	·459	357	"
Bickerstaff, Liverpool	11424	·475	415	Hedley
Neath, South Wales	11200	·468	401	"
Lump Coal, West Bromwich ...	6500	·453	226	Birmingham Gas Co.
West Bromwich...	6500	·455	227	Birmingham and Staffordshire Gas Co.
Macclesfield	6720	...	...	
Stockport	7800	·539	322	Parliamentary Return
Oldham, Watergate and Wigan Cannel, mixed... ...	9500	·534	328	Manchester
Ormskirk or Wigan Slack ...	8200	·462	290	Liverpool Old Gas Co.
Low Moor, mixed with two kinds of Slack	8000	·420	257	Bradford Gas Co.
Leeds Coal	6500	·530	263	Leeds "
Cannel and Common Coal ...	8000	·466	285	Sheffield "
Derbyshire Soft Coal	7500	·528	303	Leicester "
Ditto ditto	7000	·448	240	Derby "
Ditto ditto	7000	·424	227	Nottingham "
South Staffordshire	10933	·398	333	Clegg
Ditto, 2nd variety	10667	·395	322	"
Ditto, 3rd "	10667	·390	318	"
Ditto, 4th "	9600	·320	235	"
Forest of Dean	10133	·350	271	"
Ditto, 2nd variety	10133	·360	279	"
Welsh Coal	10000	·385	295	"
Ditto, 2nd variety	10133	·380	295	

Rule for ascertaining the Weight of Gas.

The rule to find the weight of a given volume of gas in pounds avoirdupois, when the specific gravity is known, is as follows :—Multiply the volume by the specific gravity, in order to find the number of cubic feet of air equal in weight to the volume of the gas. Then, as a cubic foot of air weighs 536 grains, of which there are 7,000 in the pound avoirdupois, multiply by 536 and divide by 7,000, or, what is the same, multiply by ·0766.

For example, take the English caking coals in the above table, the volume being 8,000 cubic feet, and the specific gravity ·420—

Then $8000 \times \cdot420 = 3360$ cubic feet of air

And $\dfrac{3360 \times 536}{7000} = 257$ lbs. avoirdupois, the weight of gas from 1 ton of coal.

Bulk for Storage.

For storage, the economic bulk of coal is 44 cubic feet to the ton, and that of coke 80 cubic feet to the ton.

CARBONISATION.

Preparation of Retorts for Charging.

After the retorts have been set, the brickwork should be well, but slowly and thoroughly, dried for several days by means of a low fire ; when sufficiently dried, the firing should be increased until the bodies of the retorts have become heated to a cherry red for iron, or bright orange colour for clay retorts ; whilst firing, a door should be loosely put on each mouthpiece, in order to keep out the external air.

Proper Heat for Retorts.

The following table gives the colours corresponding with various temperatures, according to Fahrenheit's scale :—

Faint red	960°	
Dull red	1290°	
Brilliant red (colour of red oxide of lead)	1470°	
Cherry red	1650°	Heats suitable for iron retorts.
Bright cherry red	1830°	
Dull orange	2010°	Heats suitable for clay retorts.
Bright orange	2190°	
White heat	2370°	
Bright white ditto	2550°	
Brilliant white ditto	2730°	
Melting point of cast iron	2786°	
Greatest heat of iron blast furnace	3300°	

The retorts should not be charged until they have fully attained the proper heat, or a large proportion of tar will be produced, and the gas will be proportionately diminished in quantity, and will also be of inferior quality. The proper degree of heat necessary for the carbonisation of the charges will depend considerably on the description of coal used, and the amount of volatile matter which it contains. Coal containing above 30 per cent., according to the best authorities, requires a higher heat for its distillation than that which contains it in a lesser degree.

Careful attention and practical experiment will give the manager the heat best suited to the kind of coal used, and enable him to conduct his operations accordingly. Too great a heat must be guarded against as well as one too low, as, if the retorts are too hot, part of the most valuable illuminating components of the gas will be deposited on their interior surfaces in the form of carbon.

mpers.

In maintaining the heat required, much may be done by a judicious use of the dampers; when the retorts are sufficiently hot, the dampers should be partially closed, in order to retain the heat; when they are being cooled down, the dampers should be closed by degrees, and the fires reduced gradually—great care is necessary in this particular, in order to avoid injury to the retorts, especially where clay or brick ones are used.

urability of
ie Retorts.

To ensure the greatest amount of durability of the retorts, it is essential that they should be kept at an uniform heat, as far as possible, and in constant action day and night, or, at least, never allowed to go below a dull red heat visible by daylight. The first portion of oxide which forms on the surface, when allowed to cool, cracks and falls off, leaving a new surface to be acted upon the next time it is heated; by thus being alternately heated and cooled they are rapidly destroyed. In small apparatus, and more especially in the summer months, the alternate heating and cooling down of the retorts is unavoidable, but a great deal depends on the carefulness of the workmen.

A very hot oxidising flame, mixed with an excess of unconsumed air, is unnecessary for the evolution of gas, and deleterious,

on account of its rapid destruction of the retorts; everything, therefore, depends on an uniformly steady fire. Besides the combustion caused by the hot air of the fire, the sulphur of the coal converts the surface into sulphide of iron, which melts off; and the deposit of carbon in the interior is also of considerable importance, on account of its being a non-conductor of heat. Carbon, sulphur, and the oxygen of the air are, therefore, conjointly destructive to the retorts. The retorts suffer most from the air which enters at the furnace-door when stoking, and, therefore, care must be exercised to avoid this as much as possible.

Iron, Clay, and Brick Retorts.

With regard to the comparative merits of iron, clay, and brick retorts, a great diversity of opinion exists amongst gas engineers. The durability of brick retorts is the greatest, that of clay ones the next, and of iron ones the least. The "life" of an iron retort is usually calculated as equal to the production of 700,000 cubic feet of gas, and of clay retorts to that of 1,800,000 cubic feet.

Wear and Tear of Retorts.

The usual calculation for the wear and tear of retorts is: for iron, 2½d.; clay, 1½d.; and for brick retorts, ¼d. per 1,000 cubic feet of gas produced. So far the advantage is on the side of clay and

Proportion of Fuel used.

brick retorts. On the other hand, the quantity of fuel used usually averages 50 per cent. for brick retorts, 33 per cent. for clay ones, and 25 per cent. for iron retorts, of the quantity of

Leakage of Clay and Brick Retorts.

coke produced. These remarks must be taken as applying only to works on a large scale. Brick and clay retorts also, being porous, leak to a considerable extent for some time after starting, and are, therefore, not so well suited for small works, where they are required to be frequently heated and cooled down; though, in some cases, brick and iron, or clay and iron retorts may be associated together, in the same retort-house, the brick or clay retorts being kept in constant work, and the iron ones supplying the variations of the demand. Where a number of clay or brick retorts are fixed, the use of an exhauster is almost indispensable. The heating and cooling down of clay and brick retorts must be done with much greater care than when iron ones are used, as they are much more liable to injury in these operations.

ng the it.

When the retorts have to be left for the night, the ashpit-door should be closed, or, in cases where there are no doors, the ashes should be piled round to prevent the admission of air as much as possible.

g.

When the retorts are at a good and proper working heat, the temperature should be kept up by the application of small quantities of fuel at intervals. A considerable saving of fuel may be effected by attending carefully to the fires; the fire-bars must be kept free from clinkers, the evaporating pans clear of ashes and filled with water from time to time, and the flues and outer surface of the retorts free from dust and ashes. Too much draft into the retort-house should also be avoided, on account of its cooling effect on the retorts. When carbon has accumulated to some extent in the interior of the retorts, it should be removed; the doors should be left off for some hours for the admission of atmospheric air whilst the retorts are hot, and the deposit then removed by means of an iron bar flattened and pointed at the end.

noval of bon from orts.

nomy of el.

Too much care cannot be taken to economise fuel, especially in small works, as on this depends, in a great measure, much of the success or otherwise of the undertaking, commercially. As a rule, works producing half a million cubic feet of gas per annum will require the whole of the coke made as fuel, the surplus of winter being required for the summer months. Owing to mismanagement, however, it is frequently the case that this has to be supplemented either by coal or coke procured from other works. Where the production amounts to from two to three millions of cubic feet per annum, and with iron, or iron and clay retorts, the fuel used throughout the year should not exceed 50 per cent. of the coke made.

sing red hot oke for Fuel.

Using coke for fuel whilst red-hot, and as it has been drawn from the retorts, effects a saving of about 10 per cent.; it is, however, superfluous to say, that this plan can only be carried out in large works.

se of Tar as uel.

In places where the tar commands no sale for other purposes, from the quantity produced being too small, or from local reasons, it may be used, in conjunction with the coke, as fuel—100 lbs. of

tar being equal in heating power to 150 lbs. of coke from Newcastle coal. The tar should be introduced into the furnace at a point immediately over the furnace-door frame, by means of a square cast-iron box, constructed on the principle of an ordinary water tuyere—in order to withstand the heat, which would otherwise destroy it in a short time—and provided with pipes connected to a convenient water supply for proper circulation. The tar should be placed in a suitable vessel on the top of the retort stack, and, by means of a cock at the bottom, allowed to run into a funnel and syphon, communicating with, or attached to, the tuyere box; if the tar is heated by any suitable means, say to 100°, it will run with much greater fluidity and with less attention. An arrangement which ensures a more regular and constant flow of the tar, and in such quantity as is required, is to provide *two* vessels, which may be distinguished as the reservoir and the feed cistern; the reservoir should be raised above the feed cistern so as to command it, and should be provided with a stop-cock, inserted at the bottom of its sides, and fitted with a lever and copper float; the float will regulate the flow from the reservoir to the feed cistern, and maintain the liquid in the latter vessel at an uniform level or head; the head being thus constant, the cock in the feed cistern (which should have cleaning caps easily removable) may be adjusted to the proper or desired extent, which will be, of course, maintained so long as the reservoir contains any tar. With one vessel, the head is continually varying, and consequently the flow into the syphon requires frequent adjustment; by the use of the two vessels, this inconvenience is obviated to a considerable extent. Another method of using tar is as follows:—A quantity of exhausted tan bark is obtained, and mixed with coke, bulk for bulk; a pailful or two of tar is then thrown over the heap—not quite so much as it will absorb—and it is then turned over; the mixture burns with a fine clear flame, attended with little smoke; the furnace-bars, by remaining unclinkered, admit the oxygen freely for the combustion of the fuel. Where tan bark cannot be had, peat moss, loose and dry, makes a good substitute.

W. C. Holmes & Co.,

ng of rts.

The setting of the retorts is a matter of the utmost importance; if not carefully and properly done, the result will be a great waste of fuel, or rapid destruction of the retorts, or both effects combined ; there are hundreds of instances where the retorts have not lasted more than one or two months, and others where it has been found utterly impossible to heat them at all. These are extreme cases, but the instances of injudicious and improper settings between these two extremes are very common, and cause much inconvenience and unnecessary expense. The retorts should, in the first place, be set on the best and most thoroughly tried principles, which, at the same time, should be as simple as possible, so that an ordinary village bricklayer may be competent to set any new retorts required in the ordinary course by the usual process of "burning out," &c.; and no deviation from the mode of setting first instituted should be allowed to be made on any account. Many men, with an opportunity of this kind, are very apt to indulge in any crotchets they may have on the subject, to the frequent vexation and loss of their employers—the cause of failure being generally ascribed to anything but the right one.

rtial charging Retorts.

Another method of both wasting fuel and destroying retorts, and which is very commonly practised, especially in summer, is to keep a greater number of retorts and furnaces in action than are necessary to produce the quantity of gas required ; that is, supposing that a bed of three retorts is sufficient, by being charged four times in the twenty-four hours, in charges of six hours each—two beds of retorts are kept heated the whole of that time, but only charged twice ; both sets are therefore inactive for half the day, though they require frequent stoking during that time, in order that they may be in proper working condition when charged. Cases have been known where three or four beds have been kept heated, even when required to be charged only once in the twenty-four hours. It is unnecessary to say that, under such a course of management, no dividends can be expected by the shareholders.

Weighing Coal, &c.

In order to keep a proper check on the gas-making operations, the coal to be carbonised, the coke produced from it, and the

fuel used, should be regularly weighed and taken account of, and a scoop machine provided for that purpose.

Coke and Tar v. Gas.

It sometimes happens, owing to local circumstances, that the demand for coke and tar is such as to warrant the Gas Company in so modifying the gas-making operations, as to enable them to produce the best quality and the greatest quantity of these materials, even at the sacrifice of part of the gas. In a case of this description, the ordinary Newcastle coals are the best which can be used; but there are many others which will give almost equally good results, as Silkstone, Brymbo, &c. By keeping the heat of the retorts at a lower point than is necessary when the production of the greatest possible amount of gas is the principal object, the quantity of coke and tar will be increased, with a corresponding diminution in the quantity of gas, though it should not be carried to such an extent as to materially affect its illuminating power. In some manufacturing establishments, where coke is used to a considerable extent, coals containing only a small amount of volatile matter are used, the quantity and quality of the gas being a secondary consideration.

Mode of charging Retorts.

In charging, the coals, after being broken, by means of a hammer, to lumps not larger than an egg, must be thrown in until the bottoms of the retorts are covered to the depth of 4 or 5 inches, as evenly spread as possible; a larger quantity will require too long a time to carbonise, and, as a general rule, the thinner the layers, and the quicker the coal is carbonised, the greater will be the quantity of gas generated, and the better the quality; besides, if too large a quantity is thrown in, the expansion consequent on the conversion of the coal into coke, and amounting to one-fifth more in bulk, will in all probability be injurious to them, owing to their being in a comparatively weak state at that temperature. When the end of the retort is flat, a shovelful or two of coal should be heaped up against it; this plan is found to prevent the ends from burning out too rapidly, as the heat is usually the most intense at this point; with rounded ends, this precaution is unnecessary.

Proper charge of Coal.

When the proper quantity of coal with which to charge the

retorts has been ascertained, it should be afterwards uniformly adhered to. Heavier charges can be used with Cannel coal than with common coal; the coke from Cannel does not swell so much, and does not present the same resistance to the penetration of the heat into the interior of the charge.

pleting the ging.

After the coals have been thrown in, the doors must be put on, and firmly compressed against the mouth-pieces by means of the crossbars and screws, so as to make a gas-tight joint. The doors must be previously coated with a luting of putty, composed of spent lime from the purifiers, and water, on the edges which come in contact with the mouth-pieces, and the faces or edges of the mouth-pieces must be cleared of the previous luting.

ting terials.

The luting material must be of the consistence of ordinary mortar. When the luting is required to resist a considerable pressure, the lime should be mixed with common moulding sand, in the proportion of one part of lime to two parts of sand. In works where one or two men only are employed, the retorts are charged with an ordinary shovel; with two men, one will stand on each side, in order to reduce the time occupied in throwing in the coal as much as possible, as, during this time there is necessarily a considerable loss of gas; towards the conclusion of the operation, one of the men should be left to complete it, whilst the other one brings forward the lid, which has been previously luted in the interval between the charges, and which, after the front edge of the mouth-piece has been cleared of the previous luting, by means of a trowel, is adjusted in its place. In drawing the charges, the coke should be allowed to fall into sheet iron barrows or waggons and extinguished with water.

eration of arging.

isposal of the oke.

harging by means of Scoops.

In many gas works, it is usual to charge the retorts by means of scoops, which are constructed of sheet iron, and of a semi-cylindrical form, and are provided with a cross handle at the end; these scoops being filled with coal to the amount of the charge required, in the interval previous to withdrawing the coke, are introduced into the retorts by the assistance of three men, two of whom lift up the end of the scoop by means of a bent bar on to the bottom of the mouth-piece, whilst the third

man pushes it forward into the retort as far as it will go, and, by means of the cross handle, turns it over and withdraws it, leaving the coal, which is then spread uniformly over the bottom of the retort by means of a rake; the use of scoops, however, involves the necessity of employing three men for that purpose.

Labour required or Charging.

In small establishments, two men are sufficient for working two beds of five retorts each; in larger works, and where the scoop is used, the proportion of labour is considerably less, being usually at the rate of one stoker to every 13 retorts. The duration of the charges should not exceed from 5 to 6 hours; where more than one retort, or one bed of retorts are being used, they should not all be charged at the same time, but at intervals; for instance, supposing that three retorts are being used, and that the duration of the charge is 6 hours, it is better to charge a retort every two hours, in order to maintain a more equable working of the apparatus, the greatest amount of gas from a charge of coal being generated in the first two hours. Similarly in cases where there is a bed of five or more retorts in operation, a saving of fuel is also effected by following the same method of charging part of them only at once, and the remainder in two or three hours afterwards, by which arrangement the bed is not so much or so suddenly cooled down, and can be kept up at its proper heat with greater ease and more regularity than when the retorts are all charged at once.

Duration of Charges, &c.

Registering Time of Drawing and Charging.

A black board should be fixed up in the retort-house, divided into as many parts as there are retorts, each retort being distinguished by a number or letter; when a retort is charged or drawn, the hour of the day or night should be marked on the board by a piece of chalk, opposite to its own number or letter, so that the manager or attendants can see at all times how long the charge of any individual retort has been in.

Retorts.	Charged.	Drawn.
No. 1	3 p.m.	9 p.m.
„ 2	5 p.m.	11 p.m.
„ 3	11 p.m.	5 a.m.
„ 4	4 a.m.	10 a.m.
„ 5	6 a.m.	12 noon.
„ 6	8 a.m.	2 p.m.

ects of arge remaining too long.

The charges should not be left in too long, as the last portions consist chiefly of hydrogen, nitrogen, and carbonic oxide, which have an injurious, enfeebling effect on the quality of the gas.

pplying a Light loosening the oor.

Previous to drawing a charge, and after the screw has been slackened, the door must be loosened by a tap with a hammer, and a light applied; this precaution is necessary to prevent explosion.

rawing of etorts.

The coke must be drawn out of the retorts immediately after the doors have been slackened, and then extinguished, taking care to remove it to a sufficient distance from the open retorts, to prevent injury to them from the sudden cooling induced by the steam thus generated.

learing the pright Pipes.

Immediately after the charge has been drawn, the lower end of the upright pipe, where it opens into the mouth-piece, must be cleared out of any pitchy matter or deposit which may have there accumulated, and which would, in a short time, stop the passage of the gas; a short iron bar bent to a right angle at one end, should be kept in readiness for this purpose.

Preventing the Stoppage of the upright Pipes.

In some instances a plan has been adopted for preventing the making up of the upright pipes, which appears to fully answer the purpose; it consists of a water lute formed around the outside of the lower end of the upright pipe and open at the top; to the lower part of this lute is attached a pipe provided with a stop-cock, and connected to any convenient water supply; another pipe is attached to the upper part for carrying off the heated water; the water, by contact with the upright pipe, keeps it cool, and prevents the formation of pitch. A pipe of ⅜-inch bore is

sufficient, and the supply of water may be reduced as found necessary by means of the stopcock.

Hydraulic Main. Care should be taken to keep the hydraulic main perfectly level from end to end, as, should it be thrown out of level by the settling or disturbance of the brickwork on which it is placed, the seal of the dip pipes leading from the retorts will be affected to a corresponding extent—in some cases the ends of the dip pipes will be laid bare, and in others, the seal will be injuriously increased. In small works, and where no exhauster is used, the seal of the dip pipes in the fluid contained in the hydraulic main should not exceed 1½ inches; and this should be examined and adjusted as occasion requires. The usual mode of adjustment is by altering the level of the fluid in the hydraulic main by means of the tar outlet pipe, which is altered or placed in a lower or higher position for that purpose. The hydraulic main should also be thoroughly cleaned out once a year, or oftener if necessary, and the dip pipes, bridge and upright pipes, should be also cleaned out and put in order.

CONDENSER, SCRUBBER, &c.

Effects of Temperature on Condensation. In severely cold weather, measures should be taken to protect the condensing tubes, which may be simply done by wrapping them round with hay or straw bands. The illuminating power of coal gas is considerably diminished when cooled down below 50°: much of the illuminating material is condensed, and the quality of the gas affected accordingly. The richer the gas, the more exposed is it to be acted on by a low temperature.

Name of Gas.	Hydrocarbons condensed from 1,000 cubic feet of gas, on exposure to a temperature of 32° Fahr.
Boghead	4·42 cubic feet.
Ince Hall	0·37 „
Methyl	0·33 „

rrangements or increasing r reducing the ondensing ower.

The condensing power is considerably influenced by the description of coals used: some coals, especially those from the Midland counties, yielding twice as much aqueous vapour as will be produced from Newcastle coal; for this reason, and in order to increase or diminish the amount of condensing power at pleasure, the condensers should be arranged accordingly; the ordinary ventilating or annular condensers, for instance, should be provided with plates or "dampers," for closing or shutting off the current of air through the internal tubes, and also with pipes connected to a convenient water supply, and arranged for causing water to trickle down the surfaces of the outer tubes. This is easily effected by forming the cap of each cylinder into a trough perforated with holes drilled into it in such a manner that the water will be directed on to the upper parts of the tubes, run down their surfaces vertically, and pass off to the syphon or dip boxes.

Cooling Effect of Water and Air.

The cooling effect of water evaporated on the outside of the condensing pipes is much greater than if they were submerged in water, owing to the heat which passes from a sensible to a latent state during the formation of vapour; the more rapidly the vapour is formed, the greater will be the cooling effect.

By thus arranging the condensing tubes, it will be evident that the cooling or condensing power may be increased or diminished to a considerable extent, and made to suit the varying conditions of the seasons, climate, position, coal, &c.

The relative effects of water and of air for the condensation of gas have been experimentally determined by Peclet to be as follows:—

Excess of temperature in the gas.	Quantity of heat lost by a square unit of exterior pipe surface.	
	When radiating in air.	When plunged in cold water.
For an excess of 10°	8	88
" " 20°	18	266
" " 30°	29	5,353
" " 40°	40	8,944
" " 50°	53	13,437

Huddersfield and London.

From this table it will be seen that the condensing effects by water increase in a much greater ratio than by air, in proportion to the excess of heat.

Scrubbers.

The coke or breeze in the scrubbers should be renewed twice a year, and they should, at the same time, be thoroughly cleaned out; the coke should be in pieces not larger than the fist. When in action, water should be occasionally showered over the coke, according to the size of the scrubbers, for the purpose of removing the tar and fatty oils adhering to the coke.

The operations are similar where the ammoniacal liquor is used instead of water, the only difference being that the ammoniacal liquor passes off into a well apart from the ordinary tar well, but connected to it, from whence it is pumped up into a cistern placed above the scrubber so as to command it.

The action of the scrubber is partly chemical and partly mechanical: the coke, &c., which it contains, presents a large surface to the gas in its passage through it, to which the tar and other matters still remaining in the gas after condensation adhere; the water, or ammoniacal liquor, carries off these depositions to the syphon or dip boxes: the scrubber, in this manner, relieves the purifiers to a considerable extent, as the tar would, more or less, form undercoatings to the layers of lime, and retard their proper action.

By-pass for Scrubbers.

The scrubber should be provided with a by-pass, so that the gas may be shut off from it during the operations of renewing the coke, &c.

Wash Vessel.

The wash vessel is now seldom used, being replaced by the scrubber, as it is considered that some part of the olefiant gas and heavy carburets are absorbed by the water, to the deterioration of the gas.

EXHAUSTER.

Effect of Pressure on the Retorts.

Owing to the pressure induced by the resistance to the passage of the gas through the hydraulic main, scrubbers, purifiers, station meter, &c., and by that given by the weight of the gas-holders,

a considerable portion of the carbon contained in the gas, the amount varying with the pressure given, is deposited on the internal surfaces of the retorts, thereby reducing the yield of gas, materially affecting its quality, and increasing the consumption of fuel, owing to the deposited carbon being a non-conductor of heat. The evils arising from this cause are most felt in large works, the pressure being necessarily much greater than in smaller ones; and also where clay or brick retorts are used, which, from their porosity, leak to a considerable extent under such circumstances.

Some years ago Mr. Grafton made some practical experiments on the influence of pressure on the deposition of carbon. By increasing the pressure to 14 inches head of water, the deposit amounted to one inch in thickness in a week, and in two months it had filled up nearly one-fourth of the retort. On the other hand, by taking off the whole of the pressure excepting that given by half-an-inch dip in the hydraulic main, there was scarcely any deposit at all after the expiration of four months, and with the same description of coal.

Size of Works to which an Exhauster is applicable.

Works wherein the use of an exhauster will be found to be of advantage scarcely fall within the province of the present treatise, but a few remarks may, nevertheless, be made on the subject.

The cost of working an exhauster of the smallest description in the most economical manner, including repairs, &c., varies from £30 to £60 per annum; the boiler may be placed so that the heated contents of the main flue from the retort stack are made to pass around it, in order to economise fuel; and the fuel used may consist of breeze or small coal; the labour to be shared between an ordinary night and day man, who should receive an extra weekly sum for this duty. Taking the average working cost at £45 per annum, it is now a matter of easy calculation to ascertain the size of works to which it would be an economical appendage, the result of taking off the pressure by its means being an addition of ten per cent. to the yield of gas, on the average. A gas works requiring a yearly production of 4,000,000 cubic feet of gas, including a leakage of 10 per cent., would, by

the aid of the exhauster, increase the amount to 4,500,000 cubic feet, leaving an available quantity for distribution of 4,000,000 cubic feet; or, if no more than 3,600,000 cubic feet were required for the purposes of distribution, then the quantity of coal used, of lime, labour, wear and tear, fuel, &c. would be reduced accordingly; the cost of the gas, therefore, and not its selling price, should be calculated in order to show the saving effected; assuming, therefore, that the cost of the gas at a minimum is 2s. 6d. per 1,000 cubic feet, and the extra yield to be 400,000 cubic feet, the saving will be 400 × 2s. 6d. = £50.

It may therefore be safely assumed, that an exhauster cannot be used economically in works on a smaller scale than the above, and in that case even, no material advantage is gained by its use commensurate with the increased outlay and expense.

Description and Arrangement of Exhauster.

There are many descriptions of exhausters in use, but for the smaller sizes of works in which its use is admissible, an exhauster consisting of two pumps, working together, and actuated by a small steam engine, is the simplest, and the least liable to get out of order.

A great objection to the use of exhausters, apart from their first cost and maintenance, is their liability to over-action, and drawing in atmospheric air from the open retorts, thus forming an explosive compound in the gas-holders, and reducing the illuminating power to an extent proportionate to the quantity of air thus introduced. The pressure should not be allowed to fall below that given by the dip pipes entering the hydraulic main from the retorts, so that the seal there is maintained intact. The action of the exhauster should be controlled by a small gas-holder floating in an iron tank, and regulated to the pressure required by means of counterbalance weights, &c., the rising and falling of this holder (effected by a stream of gas introduced within it) to actuate a lever which is connected with a throttle valve placed on the steam pipe, thereby adjusting the supply of steam from the boiler to the steam cylinder. In this manner, the speed of the engine, and consequently that of the exhausting pumps, is regulated to the quantity of gas which is being generated; a throttle

valve, also, actuated in a similar manner by the governing holder, should be placed in a pipe connecting the inlet and outlet pipes of exhauster, for the purpose of adjusting the pressure on the inlet side, in case the action of the exhauster should reduce that pressure to too great an extent; a self-acting by-pass valve should also be placed in the connection between the same pipes, and so balanced, that it will be opened by the pressure of the gas on the outlet side, in case that pressure should materially exceed that on the inlet side; the exhauster should also be provided with a pressure gauge on both the inlet and outlet pipes, and with a by-pass for shutting it off in case of derangement, &c. As the construction and arrangement of the exhauster, with proper appliances, as indicated above, are matters unconnected with the management, and as the management is thereby reduced within a very small compass, little more need be said here, than that the attendants should particularly note the indications given by the pressure gauges, and maintain the pressure as uniformly as possible. The action of the exhauster depends on the regularity with which this is done, and to it the attention of the workmen should be more especially directed. The charge of the engine and boiler, &c., are too well understood to require any special notice.

PURIFICATION.

Impurities in Coal Gas.

"After the gas has passed through the condensers, scrubbers, and exhauster, it has still to be deprived of the ammonia, sulphuretted hydrogen, and carbonic acid which it contains, the proportions of which, when Newcastle coal is used, may be taken at 1½ parts of ammonia, 8 of sulphuretted hydrogen, and 25 of carbonic acid, in every 1,000 parts of gas. From this it appears that the quantity of ammonia present is not nearly equal to the saturation of the sulphuretted hydrogen, and still less, therefore, to that of the carbonic acid. Hence, it is found that neutral metallic salts, such as the sulphate of iron, do not remove the whole of the sulphuretted hydrogen; nor neutral earthy salts,

such as the muriate of lime, the whole of the carbonic acid. One great cause, therefore, of the difficulty of purification arises from the deficiency of ammonia, and not from its excess, for that necessitates the employment of some other alkali, or alkaline earth, of which lime is the cheapest. Common lime, as used in a dry lime purifier, is the most effectual, the most economical, and the least hurtful agent by which the impurities in coal gas can be removed; and next to it may be classed lime used in a wet purifier, though the latter is much less effective, and is apt to leave carbonic acid in the gas. Of course this goes no further than to the absorption of the acidulous compounds contained in the gas, such as carbonic acid and sulphuretted hydrogen. But something may be learned, nevertheless, from this peculiar fitness of lime, even in respect to the removal of the alkaline compounds. Neither carbonate of lime nor the hydro-sulphate of lime possess any affinity for those naphtha vapours or hydro-carbons on which the luminosity of gas depends. Hence the lime, when fully saturated with carbonic acid and sulphuretted hydrogen, absorbs none of the light-giving principles of coal gas, which pass on untouched. A very different result, however, takes place with the oxides, carbonates, and sulphurets of the metals."

Lime as the Purifying Agent.

"Though the ammonia cannot be removed by hydrated lime, the salts of that earth possess the property of absorbing it from the gas, and as lime causes the least absorption of illuminating matter, it follows that the salts of lime are, on that account, better adapted than any other substance for the removal of the alkaline or ammoniacal impurities from coal gas. It may indeed be taken as a generally admitted fact, that when any of the salts of lime, such as the nitrate, sulphate, or muriate, are so placed that the current of impure gas may first pass through or upon them, and afterwards traverse the filled compartments of a dry lime purifier, then the greatest known perfection of coal gas purification is obtained."

Purification by Oxide of Iron.

"The impurities removed from the gas by oxide of iron are sulphuretted hydrogen and cyanogen, which form only two-sevenths, at the most, of the impurities contained in foul coal gas.

To remove the carbonic acid, which constitutes the principal remaining portion, lime is required, and in almost as large a quantity as if no oxide of iron had been employed. On sulphuretted hydrogen, the hydrated and anhydrous forms of the sesqui-oxide of iron act precisely in the same manner, except that the anhydrous oxide is more active, and evolves more sensible heat than the hydrated. In both cases water is formed, sulphur is deposited, and proto-sulphuret of iron is produced; and in both cases the water which is formed remains uncombined with the metallic sulphuret, and may be driven off by the continued action of a current of hydrogen gas, heated to 212° Fahr. Whichever form of peroxide of iron is used, the resulting product is the same, and consists of free sulphur and anhydrous proto-sulphuret of iron, mixed or unmixed with water according to fortuitous circumstances. When, however, a mixture of this kind is exposed to the air, the iron absorbs oxygen and parts with its sulphur, a small portion of which also absorbs oxygen, and produces sulphuric acid, more especially if any ammonia or other alkaline matter be present in the materials; and as no water is combined with the sulphuret prior to this oxidising process, the resulting oxide of iron must be anhydrous, whatever form of the oxide may have been originally employed. This accounts for an otherwise inexplicable fact—that when the hydrated sesqui-oxide is used the first time, it purifies only about half as much gas as on the second or third times of being used, when it has become, in a great measure, anhydrous. It has been found, indeed, by experiment, that in the first trial of a given quantity of hydrated oxide of iron, placed in a dry lime purifier, it purified only 1,500 cubic feet of gas; on its second trial, after its exposure to the air, it purified 2,400 feet; that, after a second exposure to the air, it purified 3,050 feet; and, afte another exposure, the gas purified by the same quantity of oxide of iron amounted to 4,200 feet, or nearly three times the original volume. It may therefore be assumed, not only that the hydrated oxide becomes anhydrous by the process of revivification, but that the anhydrous form is the more active condition of the two, though the greater activity of the latter does not depend upon its hydrated

or anhydrated condition, but is attributable to a peculiar molecular arrangement analogous to that of spongy platinum, nickel, cobalt, and some other substances, in which state a larger extent of surface is exposed to act upon the gas."

"One of the greatest disadvantages connected with the oxide of iron process of purification is the tendency of the sulphuret of iron to ignite and become red hot. When this happens, and is not checked at the commencement, the fire spreads through the entire mass, volumes of sulphurous acid are given off, the air becomes unfit for respiration to a considerable distance, and the oxide of iron is, in a great measure, spoilt. Nothing but great care can prevent the occurrence of such an accident, for it arises apparently from the same cause which leads to the ignition of metallic iron when in a state of minute division, such as results from the reduction of oxide of iron, at a low red heat, by hydrogen gas."

"The chemical and molecular actions that take place when sesqui-oxide of iron is exposed to impure coal gas, and afterwards to the action of atmospheric air, are not yet thoroughly understood. According to theory, not more than 16 lbs. of oxide of iron should be required to remove the whole of the sulphuretted hydrogen produced from a ton of coal; but it usually takes about four times that quantity to produce the desired effect. The oxide may be used over and over again, until the quantity of sulphur in it becomes so great that, by fusing during the revivification, it seals up the particles of metallic oxide so as to prevent their further action on the foul gas, when, of course, a fresh supply is required."

"Mr. A. King has ascertained that a much larger surface is requisite with oxide of iron purification than with lime, under equal velocities of current; and he has also demonstrated that the corrosive action of the salts generated by the revivification of the oxide, renders the use of wrought iron sieves quite inadmissible."

"The use of lime subsequently to that of the oxide of iron, for the purpose of removing the carbonic acid, is quite indispensable, and ought never to be omitted."

W. C. Holmes & Co.,

ice of Lime Purification.

"The best lime that can be obtained in this country, for the purification of gas, is that from chalk, being the purest native carbonate. The oolitic, the magnesian, and the lias limestones, are inferior exactly in proportion to the amount of earthy or foreign matter which they contain. A comparison of limes is very easily made by dissolving them in diluted acid—that which leaves the least insoluble base or sediment is the best."

eparation of me for use.

In preparing the lime for the purifiers, it should be beaten, sifted fine, and water added, until, by compression in the hand, it will retain the form thus given to it. If any lumps remain, their outsides only are acted upon, and there is consequently a waste of material; if the lime is too wet, it will cake on the shelves, and the gas will pass through in masses, or without the requisite subdivision, and consequently in a partially purified state. If the lime used is of a close caking character, it should be mixed with some fine sifted smithy ashes or sawdust, so as to make it more open and porous.

harging the Purifiers.

After the lime has been thus prepared, the shelves of the purifiers should be covered with it to the depth of 2½ inches, taking care that the thickness of the layer is as uniform as possible, and that no interstices or other places are left uncovered, otherwise the gas will not be properly subdivided or distributed over the surface, but will, in a great measure, make its way through the unprotected or thinner parts, thereby causing both waste of material and imperfect purification. When the whole of the sieves or grids have been thus prepared, the lid of the purifier must be put on and fastened down, the lute replenished with water, if necessary, the air-plug put in, and the gas may then be turned into the purifier.

In some cases moss is first laid on the sieves, and the lime spread on the top of this; the use of the moss being to subdivide the gas more effectually into the thinnest possible streams, and to bring it and the lime more completely into contact.

Quantity of Lime required.

One bushel of quicklime, when slacked and properly prepared for use, will have its bulk doubled, and will cover an area of 25 square feet, 2½ inches thick. No reliable instructions can be given as to the

quantity of gas that can be purified by means of a certain quantity of lime, as it depends to some degree on the kind or quality of the coal or of the lime itself. Mr. Clegg states that a bushel of quicklime will purify 10,000 cubic feet of gas—other engineers calculate on a bushel of lime for each ton of coal carbonised; at the Imperial Gas Works, London, a bushel of quicklime, costing 7d., purifies 10,000 cubic feet; at Cheltenham 1½ bushels costing 5d. to 6d. per bushel, are required for the same quantity; at Birmingham, where lias lime is used, the purification costs, for lime and labour, 1¼d. to 1½d. per 1,000 cubic feet, and the refuse lime is sold for two-thirds of its original cost; and at Chester, where the carboniferous lime of the Flintshire coal-fields is used, the purification costs 1s. per 1,000 cubic feet for lime alone.

Testing the Gas for Sulphuretted Hydrogen.

The proper mode of ascertaining when the lime requires renewing is to test the quality of the purified gas every day by means of a solution of acetate of lead, commonly called sugar of lead, as follows:—Dissolve a small quantity of sugar of lead in distilled, or rain water, until it is of the consistence of cream, or thereabouts; dip into it a piece of writing paper, which hold a minute or two over the jet of purified gas; if the paper is not discoloured, the gas may be considered as pure; but if a brown stain is imparted to it, the lime in the purifier, or in the one through which the gas first passes, must be renewed—the darker the stain, the more impure is the gas. The discoloration of the paper is owing to the fact that the acid has a great affinity for the sulphur in the gas, and parts with the lead in solution, which consequently appears in a state of minute division on the test paper. As this preparation of lead is an active poison, it must be labelled "Poison," and used with caution. A small cupboard should be provided for the test bottle, paper, &c., and a test-cock should also be fixed on the outlet pipe from the purifiers, for testing purposes.

Sugar of Lead Test.

Mr. Clegg recommends that test paper should be applied every day to the gas which has passed through each of the purifiers in use, and also to the unpurified gas; also that the test papers should be printed in squares, marked for each kind of gas. The test papers should be wetted with the test solution immediately

before using, and if they are desired to be preserved, they should be kept in a book for that purpose, or otherwise excluded from the light.

itrate of Silver est.

A solution of nitrate of silver and distilled water, made by adding four grains of nitrate of silver to two ounces of the water, is a more delicate test than the above; where it is used, the vessel in which it is kept should be coated with tin foil, to preserve it from the action of the light, which turns the solution black; the shades of colour are produced by a similar decomposition to that which takes place when using a solution of acetate of lead, the silver being, in this case, deposited on the surface of the paper. The sugar of lead test is, however, sufficient for all practical purposes.

'est for ammonia.

A test for *Ammonia* is as follows:—Apply either litmus paper or yellow turmeric paper, reddened by vinegar or any other weak acid, to a jet of gas; if the blue colour of the litmus paper returns, or the colour of the turmeric paper deepens to a brown, the gas contains a proportionate amount of ammonia.

Tests for Carbonic Acid.

Carbonic Acid may be detected by adding to water impregnated with the gas, a few drops of sulphuric acid, when minute air bubbles of carbonic acid gas will be rapidly disengaged. Another test is to pass the gas through a solution of pure barytes in the blue tincture of litmus, when, if carbonic acid be present, carbonate of barytes will be precipitated.

Test for Bisulphide of Carbon.

Bisulphide of Carbon.—By forcing, by means of an ordinary blow-pipe, the flame of coal gas for about a minute on to distilled water containing a little acid chloride of barium, sulphate of baryta is formed, and the presence of sulphur in the gas thus proved.

Tests for Atmospheric Air.

Atmospheric Air.—Its presence in gas may be readily detected by collecting a portion of the gas over mercury, and then passing up first a few drops of caustic potassa, and afterwards a drop or two of a solution of pyrogallic acid. If the liquid assume a blood-red hue, oxygen, indicating the presence of atmospheric air, is mixed with the gas.

Another test is as follows:—Take a two-necked pint bottle, and

fit the necks with corks, to receive each a small glass tube. Into this bottle put, first, half an ounce of anhydrous sulphate of manganese, previously dissolved in one ounce of warm water; then add two ounces of tartarised soda, also previously dissolved in three ounces of warm water; when these are well mixed together, pour in half a pint of caustic solution of potash, and agitate the whole so as to form a clear solution. After this, fix in the corks as rapidly as possible, in order to exclude the air, and push one of the glass tubes down just below the surface of the liquid, leaving the other with its open end inside the bottle near the cork; all that is now required, is to cause a constant stream of the gas, at the rate of about one cubic foot per hour, to pass through the fluid in the bottle, by means of the two glass tubes. At the beginning the fluid is clear and almost as colourless as water, and with pure gas will so remain; but if it be exposed to the air, or if the coal gas passing through it be mixed with air or with oxygen, the fluid speedily becomes of dark brown hue, and ultimately assumes the appearance of strong porter or writing ink. This change arises from the fact that the colourless protoxide of manganese is changed into the black hydrated sesqui-oxide, by the agency of the oxygen in the air. Tartarised soda is commonly known by the name of Rochelle Salt, and the solution of potash is the fluid known as liquor potassæ, and employed by medical men.

Thickness of Lime on the Sieves.

A thickness of $2\frac{1}{2}$ inches of lime on the purifier grids is found to be the best in practice, except in the case of very small purifiers, giving a comparatively small area for the gas to act upon, when the lime should be from $1\frac{1}{2}$ to 2 inches thick, according to circumstances.

Renewing the Lime.

When the lime requires to be renewed, the first one of the series through which the gas passes is shut off by means of the change valve or valves, and the gas is then first passed into the purifier which was previously the second in the series, and finally leaves when it has passed through the purifier in which the lime had been last renewed. Where two purifiers are fixed, immediately on the conclusion of the operation of renewing the lime in either of them, the gas should be caused to pass through both of them in

succession. Where four purifiers are employed, it is usual to have three of them always in work, whilst the fourth is shut off, to have its charge of lime renewed. When only one purifier is fixed, as is frequently the case in small private works, a little discretion is necessary as to the best time for renewal of the lime, which should be when the gasholder is full, and when it is not necessary to be making gas; in this case, the valve between the purifier and the gasholder must be closed, or the gas will return from the holder into the purifier, and an accident, in all probability, will occur. When a centre change valve is used, attention must be particularly paid to the mode of working it, so that no mistakes may occur—the manner of working them will, of course, vary with the description of valve used.

Attention to Working of Centre Change Valves.

Centre Change Valves.

"For working two, three, or four purifiers, one centre change valve is far preferable to having a number of slide valves. In a case where slide valves are used, if the attendant were to shut off those leading to the spent purifier before he opened the others, the consequences might be serious; the sudden check thus given to the passage of the gas from the retorts would drive the tar from the hydraulic main down the upright pipes into the open retorts, if there were any not in use, and most probably do much injury: several accidents have arisen from this cause. With one valve this cannot occur, as it is impossible to close one partition without opening another."

Centre change valves for four purifiers are now so constructed that the gas may be passed through the whole of them in succession, when the lime does not require renewal, thus virtually increasing considerably the available purifying surface.

Combined Apparatus.

The foregoing remarks apply equally to apparatus which combines a condenser, scrubber, and purifier or purifiers, together in one vessel. The lower part of the vessel must be cleaned out frequently, and the syphons kept clear, so that the flow from them may be uninterrupted.

Precaution as to Purifier House.

The purifier house should not be entered with a light, without taking proper precautions to prevent accident.

Care of Station Meter.

The indications of the station meter should be taken at a certain

given hour in the morning, say seven o'clock, and noted down in the carbonising book. The water level should also be adjusted at the same time, as it is apt to vary from evaporation or deposition from the gas; the water should also be renewed once or twice a year. If a tell-tale is attached, a fresh disc should be provided at the same time that the register of the meter is taken, and the one removed preserved for after reference or examination: an inspection of these papers will show the manager or superintendent whether the production of gas has been regular and progressive at all hours of the day and night, and supplies a good check on the operations of the workmen.

Care of Gasholders. Little needs to be said respecting the gasholder or gasholders, being merely vessels for storing up the gas as it is generated and purified, and media for its after distribution. The guide-rollers, chains, and pulleys, must be kept in working order, and so that the holders are free to move up and down without stoppage or "sticking." The holders, columns, &c., should have a coating of boiled tar every summer, the better to preserve them.

Quantity of Gas in Holders. As it is an advantage in some respects, and more especially in small works, to know the quantity of gas stored in the holders on any given day, it should be taken note of when the register of the station meter is taken. This may be readily done by the use of a wooden rod of the same length as the depth of the holders, and divided into parts corresponding to 50 or 100 cubic feet of their contents, thus:—Supposing the gasholder is 10 feet deep, and contains 5,000 cubic feet; the rod being 10 feet long should be subdivided into 50 parts of 100 cubic feet each; the end of the rod being placed at the level of the water in the tank, the quantity of gas contained in the holder can be read off at once, the rise of the crown not being taken into account.

General Remarks as to Stoppages or Obstructions. If, whilst the gas is being generated in the retorts, the tar does not flow from the syphon attached to the hydraulic main, or the passage of the gas to the purifiers is obstructed from some cause or other, the retort doors should be at once slackened in order to take off the pressure: the obstruction may arise from the making up of the upright pipe, or of the pipe leading into the hydraulic

main; an obstruction in the syphon of the hydraulic main, or in the pipes between the hydraulic main and the condenser; an obstruction may have occurred in the condenser, washer, scrubber, exhauster, purifiers, station meter valves, connecting pipes, or the syphon boxes, including those in the gasholder tanks, or from the "sticking" of the gasholder, owing to the friction or displacement of the guide-rollers, &c. If the obstruction is beyond the purifiers in action, the lutes will, in all probability, "blow," as will also the syphon-boxes between them and the hydraulic main, according to the depth of seal possessed by them; the greater the number of the syphons which are affected, the more removed will be the obstruction from the retort stack. The remedies will generally suggest themselves; a good indication of the working of the apparatus is afforded by the sounds caused by the passing of the gas through the fluid in the hydraulic main; if the ebullition is heard to be regular and steady, it is more than probable that no obstruction exists; but if it is violent and irregular, or not heard at all, it may be taken at once for granted that there is a stoppage.

Deposition of Naphthaline.

A frequent cause of stoppage is the deposition of naphthaline in the pipes; where this substance is likely to be troublesome, the pipe leading from the hydraulic main to the condenser should be prolonged, so as to keep the gas, &c., in contact with the coal-tar, which contains naphtha, as much as possible, coal naphtha having a great affinity for it; coal naphtha may also be used for this purpose in the scrubber instead of water, the syphons of the scrubber being so arranged, that the naphtha can be pumped up again and re-used; if, however, as sometimes happens, the naphthaline has been deposited in an inaccessible place, such as the pipes leading into the gasholders, there is no alternative but to attach a steam pipe from a boiler and dissolve it. In works where an exhauster is employed, actuated by a steam engine, there will be little difficulty in so doing. A valuable adjunct to a works making three or four millions of cubic feet per annum and upwards is a small

Portable Steam Boiler.

portable steam boiler, which may be used on occasions of this kind, and also for clearing the condensing tubes and other parts of the apparatus periodically.

Huddersfield and London.

By-pass Valves. In order to avoid the necessity of slackening the retort doors, as much as possible, the scrubber or washer, the exhauster, and the station meter, should be provided with by-pass valves, so that the gas may be diverted from any of these parts of the apparatus in case of stoppage.

Syphons. All syphons should be examined carefully and regularly at least once a week, to ascertain if they are in working order.

Pressure Gauges. Pressure gauges should also be fixed in different parts of the apparatus—say, to the pipe leading from the hydraulic main to the condenser, to the inlet and outlet pipes of exhauster, and to the outlet pipes of the centre change valve and station meter.

In its simplest form, the pressure gauge consists of a bent glass tube, one end being open to the air, and the other end connected to the gas supply; it is partly filled with common or coloured water, which, when no pressure is exerted on it, stands at the same level in both legs; the space, both above and below this line or level, is divided into inches and tenths of an inch. When the gas is turned on, the water is depressed on that side to the extent of the pressure given, and raised on the open side; the reading being equal to the sum of the indications on each leg when added together; that is, supposing that each leg indicated $1\frac{3}{10}$ inches, the actual pressure given would be $2\frac{6}{10}$; or, what is the same thing, the distance between the surfaces of the two columns of fluid gives the pressure. In reading off, care should be taken to allow for capillary attraction, which affects the levels of the liquid to some extent.

Painting and Tarring the Apparatus, &c. All the ironwork exposed, or above ground, should be tarred over or painted every summer. All valves on the works should be examined at the same time, and put in proper working order. The apparatus generally should also be thoroughly seen to, and any deficiencies supplied or made good.

Care of Buildings, &c. The retort-house or purifier-house, and the buildings generally, should be kept clean and in good repair and order, as also the yard. The gasholder tanks should be filled with water to the proper level, to compensate for evaporation, &c.

W. C. Holmes & Co.,

THE GOVERNOR.

The Governor is a machine for controlling and equalizing the pressure of the gas during its distribution in the street mains—the gasholder giving the initial pressure, which the governor reduces according to the quantity of gas required at certain parts of the day or night.

Variations of Pressure.

The pressure of the gas in its passage through the mains is influenced by various causes; the leading main may be of great length and have numerous contractions, bends, or angles, and the supply of gas to the burners will be consequently unequal and irregular: those burners which are situated nearest the works will be supplied with a fuller stream of gas than those which are nearer the extremity; or a difference in the levels of the various districts supplied will affect the distribution in a similar manner: those burners which are at the highest points will receive a greater supply than those which are lower. Again, the pressure is influenced to a much greater extent than by either of the above causes, by the fluctuations of the demand. For instance, the greatest consumption of gas will probably take place in most towns or villages between six and eight o'clock, p.m.; during this time the pressure will be reduced by the requirements of the demand to its lowest point, but immediately that a number of the burners are shut off, say one-half, the pressure is considerably increased, and the flames of the remaining burners and street lamps enlarge in size to an unnecessary and wasteful extent, and require reducing or turning down. The leakage in the mains is also considerably influenced by the pressure.

Adjustment of Pressure.

The governor, therefore, is used for the purpose of adjusting the supply to the demand, giving the greatest pressure at the hours when it is usually most required, and reducing it at other times. It is not, however, altogether a self-acting machine; the pressure must be adjusted by adding to, or diminishing, the weight of the regulating cup of the governor to suit the varying requirements of the district lighted; if it is a manufacturing district, the greatest

pressure in winter will be required in the evening for two or three hours, to be reduced afterwards for the public and remaining private lights—again reduced for the night after the public lamps have been shut off—increased again from six to eight, a.m., and then reduced to its minimum for the day. No rule can be given for the proper pressure at these times, as it depends on so many circumstances: as, the length and size of the mains, contour of the district lighted, distribution of the lights, and the purposes for which they are required—as for cooking, manufactories, street lamps, &c. It seldom happens that the same circumstances occur in any two towns or villages, even of the same size; but in many of these places where the consumption varies from half a million to three or four millions of cubic feet per annum, the greatest night pressure necessary may be taken at one inch, and the lowest or day pressure four-tenths of an inch head of water.

Placing of Governors.

In towns where the gas ascends to a considerable elevation from the works, there should be a governor provided for each 30 feet of rise, for the purpose of more fully equalizing the supply; and this rule should also obtain in the case of a descent or fall from the works, the pressure in the mains varying at the rate of one one-hundredth part of an inch, for every foot of rise or fall. For lighting all ordinary districts, one governor only is necessary, placed on the leading main from the gasholders; but where there is more than one leading main, there should be a separate governor for each.

Attendance on Governor, &c.

Every governor should be provided with a pressure gauge placed on the outlet pipe, and also with convenient weights for adjusting the pressure; the tank should be kept filled with water, and the regulating holder itself seen to, that it works freely in its tank, and with as little friction as possible. The cone and valve should be examined occasionally, and cleaned; and the by-pass, with which all governors should be furnished, kept in proper order, and not, as is frequently the case, allowed to set fast. The pressure given, both night and day, should be noted in the carbonisation book.

Registering Pressure Gauges.

In large works a registering pressure gauge is frequently used, by means of which a check is provided against any irregularities

in the adjustment of the pressure by the attendant; the register papers being renewed every 24 hours, and those which have been used retained for examination or reference.

Regulating the Pressure by Counter-weights.

In cases where no governor is fixed, the pressure should be regulated by means of the counter-balance weights.

MAIN PIPES AND SERVICES.

Leakage of Mains.

The leakage of the Main Pipes is a subject of great importance, and should receive particular attention from the managers of gas works. The usual calculation, even when erecting new works, is 10 per cent. of the whole of the gas produced: in many cases it amounts to 25 or 30 per cent., and even more than this; instances have been known, where the leakage has exceeded 75 per cent. It is, however, unfair to ascribe the whole of the gas unaccounted for, or the difference between the station meter registrations and those of the consumers' meters, together with the quantity supposed to be consumed by the public lamps, to defective mains and joints, as there are a variety of circumstances generally, which have a considerable bearing on this so-called leakage. For instance, the water level of the station meter is frequently allowed to stand higher than it should do, and it will, consequently, register more gas than is actually made, the production per ton of coal being raised in a corresponding degree, to the apparent credit of those in charge of the gas-making operations. There is also to take into account, the gas consumed on the works and in the managers' houses, condensation in the mains, defective registration of the consumers' meters, difference between the actual and the calculated consumption of the public lamps, which is often considerable—leakage through the porosity of the mains themselves, difference in the quantity of gas contained in the holders at the commencement and conclusion of the period for which the leakage is taken, &c. Some of these sources of leakage may appear to be trivial, but it must be borne in mind, that in a small

works, where the consumption is limited, especially in summer, they all have their influence.

Testing of Mains.

The mains should be tested every summer, and all leakages made good. The testing should be effected by means of the governor; notice should be given to all the consumers to shut off the gas at the main-cock, and an attendant should be sent round to see that this is done; the governor holder should then be allowed to fill with gas, and afterwards shut off from the gasholders, and, its contents being known, the time must be carefully noted in which it is emptied by the leakage of the gas, and the pressure taken. For instance, supposing that the holder contains 30 cubic feet, and that it is emptied in half an hour at a pressure of six-tenths of an inch, then the percentage of leakage on an annual production of 5,000,000 cubic feet will be about 10 per cent., or varying from 6 per cent. in the depth of winter to 15 per cent. in the middle of summer; but if the same holder is emptied in half that time, the leakage will be, of course, double the above amount, and immediate steps should be taken to reduce it, or to discover the cause.

Detecting Leakages.

Leakages are of frequent occurrence both in public lamps and private services, especially at their connection with the main pipe, and particular attention should be paid to them. A good plan for detecting leakages is to drive a pointed iron bar into the ground, alongside the line of mains which is being examined, care being taken not to break or disturb the pipes; the bar is then withdrawn, and if there is a leak in the vicinity of the hole thus made, it will be at once detected by the smell; if it is faint, drive the bar down again a yard or two further on the line of main each way, and ascertain if the smell is stronger, and in which direction; the leakage will thus be found readily. The ground must then be opened, and the leakage stopped. The street syphons, also, form a pretty good guide or index to the condition of the mains, as they will, of course, fill much more rapidly when there are leakages than when the pipes are sound; they will also show in what particular locality the leakages may be expected to be found. The syphons should always be examined monthly.

W. C. Holmes & Co.,

Repairing Joints, &c.

In the case of the fracture of a main pipe, or of a joint being required to be repaired or re-made whilst the gas pressure is on, it is the practice to make use of bladders fitted with stop-cocks, to prevent leakage during the operations; for this purpose two bladders are provided, and a hole is drilled and tapped in the main on each side of the place where the repairing operations are to be carried on, and at a sufficient distance from it; a bladder is then introduced into the main through the holes thus made, to the side furthest from the joint or fractured place, and then inflated so as to completely fill the main, when the stop-cock is turned, so as to retain it in that condition. When the operations are completed, the air is let out of the bladders, which are then withdrawn, and the holes in the main made good by screwing in ordinary gas plugs.

Amount of Leakage.

In works to which these remarks more particularly apply, the leakage should not exceed 5 per cent. of the yearly production. Much depends, however, on the length of the main pipes, as compared with the consumption on them, and also on the depth at which they are laid, which should be sufficient to avoid any liability to surface disturbances or variations of temperature.

Plan of Mains.

In all cases, there should be a map of the streets, showing the lines of mains, their position, size, positions of the syphons and street lamps, and the private services. Much inconvenience often results for want of reliable information on these points, owing to change in the management, want of attention on the part of those in charge, &c. Instances have been known where private consumers have been burning gas for years without the knowledge of the gas company, and, of course, without paying for it, owing to there being no record of any services having been put in. A proper account of all new services, and also of services taken up or cut off, should be kept, and the plan corrected to that account periodically.

Laying Services.

All new services should be first examined carefully, to see that there are no flaws or cracks in them, and then coated with hot tar; particular care must be taken to prevent leakage at the junction of the services and main pipes, and also at the joints.

Huddersfield and London.

Table of the Square Roots of the Specific Gravity of Gas from ·350 to ·700.

·350	·5916	·395	·6285	·440	·6633	·485	·6964
·355	·5958	·400	·6325	·445	·6671	·490	·7000
·360	·6000	·405	·6364	·450	·6708	·495	·7035
·365	·6041	·410	·6403	·455	·6745	·500	·7071
·370	·6083	·415	·6442	·460	·6782	·505	·7106
·375	·6124	·420	·6481	·465	·6819	·510	·7141
·380	·6164	·425	·6519	·470	·6856	·515	·7176
·385	·6205	·430	·6557	·475	·6892	·520	·7212
·390	·6245	·435	·6595	·480	·6928	·525	·7246
·530	·7280	·575	·7583	·620	·7874	·665	·8155
·535	·7314	·580	·7616	·625	·7905	·670	·8185
·540	·7348	·585	·7648	·630	·7937	·675	·8216
·545	·7382	·590	·7681	·635	·7969	·680	·8246
·550	·7416	·595	·7713	·640	·8000	·685	·8276
·555	·7449	·600	·7746	·645	·8031	·690	·8306
·560	·7483	·605	·7778	·650	·8062	·695	·8337
·565	·7517	·610	·7810	·655	·8093	·700	·8367
·570	·7549	·615	·7842	·660	·8124	...	...

PUBLIC LAMPS.

Care of Lamps. The Public Lamps should be regularly cleaned, and the burners put in proper order ; the posts should be kept in a vertical position, from which they often deviate, especially after hard frosty weather.

Meters for Street Lamps. When the gas supplied to the public lamps is paid for by the quantity consumed, it is an advantage to both the public and the gas company to have meters fixed to half a dozen or more lamps in different parts of the town or district lighted, and the average consumption of the whole of the lamps taken from them. Lamp

ngths, the S

ND TENTH

	4	
1·00	0·5	1
	1761	
	1526	
942	1366	1
	1245	1

AND TENTH

	24	
2·0	0·5	1
	187500	
	155000	
	135600	
	108600	155
	93800	135
137200	84000	119
112500	77500	108

tained by multiplyi

arge of gas when th

columns which will hold a meter in their bases, and which are provided with doors and locks, are the best arrangement for that purpose.

ting of st Lamps by hes.

The lighting of lamps by means of torches placed on the ends of long rods has become common during the last few years. By their use ladders are dispensed with, excepting when the lamps require cleaning; and the lighting and extinguishing occupies at the least one-third less time.

zing of ices.

A frequent cause of annoyance and trouble is the liability of the services of street lamps to be frozen up, especially at the point where they emerge from the ground to pass up the columns. This inconvenience is most felt in the north of Germany and in Russia; the best remedy is to use a small portable steam boiler, capable of being carried by a labourer, and having connections for attaching to the top of the service pipe, after removing the burner.

Number of hours Gas is burnt in each Month, Quarter, and Year.

	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Midsummer Quarter.	Michaelmas Quarter.	Christmas Quarter.	Lady-Day Quarter.	Total of Year.
From dusk to 6 o'clock	...	...	2	31	62	80	65	33	4	...	...	...	...	2	173	102	277
7 "	...	14	22	62	92	111	96	61	31	4	...	...	4	36	265	188	493
8 "	...	40	52	93	122	142	127	89	62	28	4	...	32	92	357	278	759
9 "	13	71	82	124	152	173	158	117	93	58	29	8	95	166	449	368	1078
10 "	44	102	112	155	182	204	189	145	124	88	60	38	186	258	541	458	1443
11 "	75	133	142	186	212	235	220	173	155	118	91	68	277	350	633	548	1808
12 "	106	164	172	217	242	266	251	201	186	148	122	98	368	442	725	638	2173
All night	217	307	345	421	473	527	512	411	382	295	242	195	732	869	1421	1305	4327
Morn. from 4 o'clock	...	16	48	80	110	137	137	98	71	28	2	...	30	64	327	306	727
5 "	...	...	18	49	80	106	106	70	40	3	...	...	3	18	235	216	472
6 "	...	...	...	18	50	75	75	42	9	...	...	...	...	...	142	126	269
7 "	...	...	...	...	20	44	44	14	...	...	...	...	...	...	64	58	122

For Sundays off, deduct one-seventh.

Huddersfield and London.

CONSUMERS' METERS.

Care of Meters. All wet meters should be examined at least once a month, and the proper water level maintained; particular attention should also be paid to the dry meters; should any irregularity be suspected in either description of meter, it should be at once compared with a test meter; the test meter should, however, be as large as the meter under examination; the nearer the two meters are in capacity, the more accurate should be the results; if the meter to be examined is larger than the test meter, the latter will be worked above, or the former below, its proper speed, causing error in either way.

Testing Meters.

Position for Meter. The meter should be fixed in such a position that it is easily accessible to the inspector, and not exposed to an undue degree of either heat or cold, but at the same time, so that it may be readily connected to the street mains, and to the pipes leading to the burners. A plan which is frequently practised, is to enclose the meter in a wooden box or case, provided with door, lock and key; it is thus protected from injury and from any great variations of temperature.

Use of Glycerine for Wet Meters. Owing to the inconveniences attendant on the use of water for gas meters, a solution of glycerine has been sometimes substituted, as not being affected either by the extreme heat of summer, or by the greatest amount of cold to which gas meters are liable. The solution should be of such a degree of concentration as to contain from 40 to 45 per cent. of anhydrous glycerine, which solution will have a density of from 1·105 to 1·117.

Rental of Meters. In all cases gas companies will find it to be to their advantage to provide the meters for consumers at a fixed rental, which will repay them for the outlay and for repairs: the usual rate of charge being 10 per cent. on the cost, including fixing; this gives them the right to remove any meter which they may suspect to be incorrect in its registrations, or too small for the amount of gas consumed, and to fix another in its place; cases

often occur where a meter put down to supply, say ten lights, is expected to pass sufficient gas for thirty or more lights.

CEMENTS.

The following are a few general instructions for making joints connected both with the apparatus and main pipes.

Iron Cement for Joints.

Common iron cement.—To one ounce of sal-ammoniac and one ounce of flour of sulphur, add thirty-two ounces of *clean* cast-iron borings, mix all well together, and keep the composition dry. When it is wanted, add a little water, and when brought to a proper consistence, let it stand a few hours before using; it must then be rammed into the joint, with a flat caulking chisel and hammer, until quite hard. Mr. Watt found the cement was improved by adding some fine sand from the grindstone trough.

Another method of making iron cement is to mix together two parts of finely sifted unoxidised iron filings with one part of perfectly dry and finely sifted powdered loam; the mixture to be kneaded together with strong vinegar until a perfectly homogeneous mass is formed, when the cement is ready for use. It resists fire and water, and quickly hardens.

Cement for Mouth-pieces and Retorts.

The cement used for connecting iron mouthpieces to clay retorts consists of iron borings mixed with an equal quantity of fire-clay; it is made of the consistence of mortar, and is spread evenly over the joint. Some managers use fire-clay only for the joints of both iron and clay retorts; and others use spent lime for the same purpose in the form of mortar.

Cement for Joints of Upright Pipes.

A cement recommended for the joints between the mouth-pieces and the upright pipes, and which are very likely to become leaky from the expansion of the retorts, consists of moist chalk or whiting, mixed with half its weight of common salt, compounded with water into a plastic state, and applied like ordinary putty.

Lead Joints for Mains.

For lead joints, put the two ends of the pipes into their proper places, then ram a piece of gasket or tarred yarn to the extremity of the socket, and around it, to prevent the lead from running

into the interior of the pipe, and after forming a luting of clay at the outside to receive the molten lead, pour in the lead until the annular space between the spigot and socket is full; the excrescences must then be dressed off and the face well caulked. The ends of the pipes must be dry before receiving the lead.

Turned and Bored Joints for Mains. For turned and bored socket and spigot joints, coat the spigot end with stiff red-and-white lead paint, and after insertion into the socket, drive it carefully, but well, up with a wooden mallet.

RESIDUAL PRODUCTS.

The residual products obtained from the distillation of coal are coke, tar, and ammoniacal liquor, which are applied to a variety of useful purposes.

Coke. Part of, and in some cases, all the coke produced from the coal is used as fuel for heating the retorts, depending on the size of the apparatus. When there is a surplus of coke, it may be introduced with advantage into malt-houses, and for other drying or heating purposes; and also into dwelling-houses for the kitchen or sitting-room fires; and when the proper method of using it is understood, it will be preferred to any other fuel. The fire should be made with coal before the coke is put on, which latter should be broken into small pieces, in order that it may more readily ignite; and, before it gets too low, more should be added, and the fire kept compact and not stirred up, but the bottom kept clear from ashes, to allow the air to pass upwards through the fire. When a coke fire is properly made, it will burn for some hours without any further trouble.

Tar as Manure. Tar, when properly used, is an excellent manure for potatoes, &c., and also a preventive of disease in the crops. The idea that potatoes thus manured will have a tarry flavour is erroneous, and has as much reason for its belief as that they will taste of any other manure. In Scotland the method of using it is as follows:—Whilst storing up manure in the dung-court, a layer of common farm-yard manure is deposited of about one foot in

depth, and when levelled, sprinkled over with a good coating of tar; this is covered with another layer of manure and tar, similarly applied, until the heap is made up. The decomposition of the heap is not retarded in any way, but a singular change in the nature of the tar itself takes place; its oily character shortly disappears by its absorption in the manure, and a carbonaceous powder remains in its place. Manure thus prepared has invariably been found to produce much richer cereal and green crops than ordinary, and abundantly repays the trouble and cost.

Ammoniacal Water as Manure.

Ammoniacal water is generally used as a stimulant to young grass, barley, and oats. The best mode of application is to reduce its strength by adding an equal bulk of water, and by means of an ordinary liquid-manure cart it is then passed over the young sprouting crop in a gentle shower. This method, however, is the preferable one only when likely to be followed by rain. Another method more frequently adopted, as being the most convenient, is to saturate a large heap of mould with the liquid in its undiluted state, mixing the mass thoroughly, and stowing it closely together, and at convenience using it as a "top dressing." This is stated to be very efficacious, especially on grass crops, and it is much safer than the ordinary sulphate of ammonia, as generally applied.

Spent Lime as Manure.

The spent lime from the purifiers is a valuable manure for grass land; it should be used at the rate of three to four tons per acre, and not more. The best time for applying it is in the winter, or from October until the end of April. From this application excellent crops of hay-grass are produced, and the after grass is good and healthy. Cattle feed well off land on which it has been laid, and it is considered to be one of the best substances known for eradicating foul herbage, without injury to the finer grasses and clover.

Treatment of Tar for the production of various substances from it.

Dead Oil, Naphtha, &c.

"Tar may, in a practical sense, be considered as consisting of two fluids, each of a very composite nature; first, a rather volatile fluid, or naphtha; and, secondly, a more fixed and oily compound, generally called dead oil. These really consist of several different hydro-carbons, to which a variety of names have been given. If

Huddersfield and London.

any of the ordinary coal tars be subjected to distillation, the product, at first, is a naphtha, almost colourless. This is soon succeeded by a dense fluid, having a pale yellow colour; after which a still heavier, and more deeply coloured fluid makes its appearance; and this is followed by a dark, viscid substance, which solidifies at the ordinary temperature of the atmosphere; the several substances of which each of these products consists having more or less volatility. They are not, however, capable of being separated from one another by mere distillation. Besides the naphtha or benzole contained in coal tar, and the oily matter less volatile than naphtha, and resembling, if not identical with eupione, there are also naphthaline, paranaphthaline, copnomore (an oil that smells like smoke), picamare (an oil possessing an extremely hot and bitter taste), and paraffine in small quantity; there is also always a portion of ammonia present. The best mode of treating coal tar is to distil it by means of a Coffey's still, which consists essentially of a series of shallow trays, placed one above the other, and having an arrangement by which a current of steam can sweep over and under the trays, thus heating a small descending stream of the tar, and volatilizing the benzole and eupione, leaving the other ingredients, excepting a small quantity of naphthaline, to descend from tray to tray to the bottom of the apparatus. The product of this distillation, when condensed in a worm, is therefore an impure benzole or naphtha, which may be purified as follows:—To a given portion of the naphtha, add from five to ten per cent. of oil of vitriol, and mix the whole well together for some time; when the mixture is complete, throw in about five per cent. of the peroxide of manganese, and stir it again. As the ingredients become sufficiently mixed, the naphthaline and other impurities of the naphtha combine with the oil of vitriol, and fall to the bottom in the form of a thick tar, from which the supernatant naphtha must be carefully poured off, and again distilled by steam into a clean vessel, when, after separating from the water condensed with it, it will be found quite colourless and pure. After parting with its benzole, the tar is much thicker, and is too frequently looked

upon as worthless, or as only fit for the preservation of rough wood-work. But when freed from the water it contains, by standing for some time in a warm situation, it will yield, by distillation and other treatment, two substances of considerable value, and in much demand. The first of these is a heavy, thick oil, applicable to the lubrication of large machinery; the other is paraffine, a material that is quite equal to spermaceti for candle-making. The fluid pitch is introduced into an iron still, provided with a refrigerator, the temperature of which should not, however, be lower than 55° Fahr. Fire being applied to the still, and cautiously increased, the thick tar is soon resolved into three fluids, which, as they follow each other in succession, may be collected separately. First, a mixture of water and naphtha, with a volatile oil, make their appearance, being of a pale yellow tint, and much contaminated with naphthaline; afterwards a green-coloured, and heavier fluid, begins to be evolved, which changes to a dark red, and is eventually soon followed by a greenish-yellow and thick fluid, of the consistence of butter when cold, and which contains numerous small crystals of paraffine. The first of these products is almost worthless, owing to the quantity of naphthaline in it. It may, therefore, be employed as fuel; but the two last afford, by proper treatment, an oil possessing lubricating properties no way inferior to the finest sperm oil. This fluid, in its rough state, has, under the name of "dead oil," entered for many years into the composition of cart-grease and other lubricating mixtures, and has also been employed in making printer's ink and lamp-black."

Paraffine Oil from Coal Tar.

"The ordinary treatment of dead oil, for the production of marketable oil and paraffine, is as follows:—It is first re-distilled, and the product allowed to stand some hours in a cool place, to favour the deposition of naphthaline, which is then separated from the oil. This distilling process requires to be repeated two or three times, according to the quality of the dead oil operated on. That from cannel coal requires less care than the oil from common coal; and also, where low heats have been employed in the production of the tar, the purification is easier. Newly distilled

dead oil, after the above treatment, has a pale yellow colour, with a peculiar opalescent appearance when viewed by reflected light, but it gradually deepens, and assumes a purple or deep bottle-green hue, so intense as to seem almost black; a jet of steam is next driven through the oil for some hours, to dissipate the naphthaline and any naphtha that may have been formed, after which the whole is allowed to cool and settle, that the water it contains may separate. When the oil is decanted from the water, it is placed in a kind of churn, and thoroughly mixed with 10 per cent. of its bulk of strong sulphuric acid; after perfect mixture, the materials are run into a convenient vessel, and allowed to stand for 24 hours, when the oil is poured off from the impurities. The further processes of washing the oil with water, and subsequently with a solution of caustic soda, are gone through, after which the mixture is left for the oil to separate. The oil, now deprived of the greater part of its impurity, is of a reddish orange colour. It is then placed in an iron still provided with an iron worm, and the products of its distillation are received into three separate vessels, at different periods of the process: they consist, first, of light lamp oil, to the extent of about one-fifth of the whole oil put into the still; secondly, heavy or lubricating oil, in the proportion of three-fifths of the whole; and the remainder consists chiefly of paraffine. The lamp and lubricating oils are each still further purified by boiling them for an hour or two upon a solution of some acidulous salts, such as bisulphate of potash or alum."

"100 gallons of dead oil will furnish, by the foregoing process, about 12 gallons of lamp oil, 36 gallons of lubricating oil, and 46 pounds of impure paraffine, which yields, on purification, from 16 to 18 pounds of the pure article."

Lubricating Grease from Coal Tar.

"A very superior grease for lubrication is prepared by taking 45 gallons of the second or heavy oil, and boiling it in a cauldron, with a coagulum formed of 30 lbs. of No. 2 pale yellow soap, previously dissolved in 20 gallons of water, and to which 14 lbs. of muriate of baryta has been added. This coagulum must be washed with warm water and dried, previous to its being added

to the oil, which latter must be kept stirred until the whole is dissolved. The gelatinous mass is then to be put into barrels, and is ready for use."

Paraffine from Tar.

"Paraffine is a substance of great interest, and though contained in common coal-tar only in small quantities, it is much more abundant in the tar from Boghead and other kinds of cannel coal. If the viscid tar, after distillation, be exposed for some time to the air, and then pressed, an oily fluid separates, and leaves a brown scaly mass behind. When the residue is mixed with its own bulk of strong oil of vitriol, and kept at a temperature of 220° Fahr. for some hours, with repeated agitation, a clear, colourless substance, in a fluid state, rises to the top, leaving a dark black-looking fluid below. On setting the whole aside to cool, the clear supernatant fluid will solidify, and may then be removed and re-melted in water to purify it; whilst the oil of vitriol, and other impurities which constitute the dark fluid, must be rejected. As thus procured, coal tar paraffine is a perfectly white, inodorous substance, melting at a temperature of 105° Fahr., but continuing fluid at a much lower temperature. It crystallizes on cooling, into large, feathery-looking plates, and when cold may be mistaken for spermaceti. It has been suggested as better applicable than any other material for making a standard photometric candle, as it burns with remarkable uniformity. Its illuminating power is a little higher than that of spermaceti."

Colouring Matters from Coal Tar.

"M. Quinon, of Lyons, discovered that by acting on naphtha, and even on impure coal tar itself, with strong nitric acid, the tar is speedily resolved into picric acid, a substance capable of communicating the most beautiful yellow tint to silk and woollen goods. He heats three parts of nitric acid to a temperature of 140° Fahr., in a capacious vessel, and gradually adds one part of dead oil, having previously discontinued the application of heat. As much more nitric acid as at first used is then mixed with it, and the whole is heated to the boiling point, and evaporated to the consistence of syrup. This solution, diluted to the desired shade of colour, at a temperature of 80° to 104°

Fahr., is employed directly, without any mordant, for dying silk, which is immediately dried, without undergoing any previous washing. Picric acid has long been known under different names by chemists, and has generally been described by English chemical writers under the name of carbazotic acid. The materials used for its production, before the employment of coal tar for the purpose, were aloes and indigo; the yellow stain which nitric acid communicates to the skin arises from the production of picric acid. Not only yellow dyes, but reds, purples, and almost every colour that is obtainable from madder and cochineal, can be extracted from coal-tar."

Coal Tar Pitch. "The pitch remaining after the distillation of the coal tar is used for various purposes; when mixed with small coal, it forms artificial fuel. Asphalte foot-pavement is composed of small gravel and broken stone imbedded in pitch; and though it is not now used for streets, it has been applied to make floors for granaries, barns, &c., as well as foot-pavements in some provincial towns. Pitch is also a principal ingredient in roofing-felt, being used to give consistence to refuse tow and hair. This substance is passed through heated rollers in a bath of bituminous matter, and afterwards subjected to heavy pressure, which renders it compact and waterproof. Pitch is now often further submitted to distillation in ovens constructed of fire-bricks, when it affords about 25 per cent. of what is called coke oil, and 50 per cent. of pitch coke; 25 per cent. of the original pitch being lost in the operation. The ovens are each charged with about two tons of pitch, and the distillation is continued for twelve hours. The coke oil is added to the pitch oil for creosoting purposes, and the coke is valuable for iron-founding, in consequence of its entire freedom from sulphur."

Lamp Black from Coal Tar. "Lamp-black is also produced from coal tar; the tar is previously freed from ammoniacal liquor and acid by washing with lime-water, and the water held in suspension is expelled by distillation at a low heat. The pure portion of the tar is then admitted into a horizontal main, pierced with holes at the bottom, into which a number of jets are inserted, and through which the

tar flows. Wicks are introduced into the jets to facilitate the burning of the tar, which is further assisted by heating the main by a furnace underneath. Hoods are placed over the jets to receive the smoke, which is conducted by tubes from the hoods into boxes, in which the heaviest particles of the carbon are deposited; after which, it passes through a series of canvas bags, about eighteen feet long, and three feet in diameter, connected at the top and bottom alternately, so that the smoke passes entirely through them, and lamp-black of the finest quality, used as pigment, is collected from the sides of the bags. A more simple process of obtaining lamp-black by the combustion of coal tar is to allow it to pass through a large orifice, and to admit only a sufficient quantity of air to burn the hydrogen, by which means the carbon is deposited in the form of a black powder, of extreme lightness."

Products obtained from Ammoniacal Liquor.

Ascertaining the Value.

"During the distillation of the ordinary kinds of Newcastle coal, the quantity of ammonia given off by each ton is equal to the manufacture of about 24 lbs. of sulphate of ammonia, but this quantity varies with the heat used in distilling even the same kind of coal; the higher the temperature the greater the tendency to convert ammonia into cyanogen. Of this ammonia, more than one-third is contained in the ammoniacal liquor, and somewhat less than two-thirds is combined with the impure gas; but this proportion fluctuates with the efficacy of the condensers. The gas liquor from a ton of Newcastle coal amounts ordinarily to almost ten gallons, each gallon of which will yield from twelve to thirteen ounces of commercial sulphate when properly treated with sulphuric acid; the strength of the liquor being roughly determined by the quantity of strong sulphuric acid it neutralizes. This method of determining the quantity of ammonia in the liquor is by no means accurate, for it takes no account of the ammonia combined with the muriatic acid, which, in the case of Newcastle, but not of inland coal, is equal to about one-sixth of the whole; and the litmus paper, used as a test, is apt to be bleached by the action of the sulphuretted hydrogen contained in the liquor, and thus to mislead the operator."

Huddersfield and London.

"A more exact mode of ascertaining the value of ammoniacal liquor is the following:—Add an excess of muriatic acid to a given quantity, then expel the sulphuretted hydrogen by boiling for a few minutes, and transfer the liquor to a glass retort containing an excess of slaked lime, from which it is carefully distilled into a receiver containing water, and kept cold by ice. When nearly the whole of the fluid in the retort has passed into the receiver, a few drops of the solution of litmus are added to it, so as to render it of a purplish-blue colour, and then diluted sulphuric acid in the proportion of 49 grains of acid to 121 of water is added, until the fluid becomes distinctly red. It will require 170 grains of the diluted acid to neutralize 17 grains of pure ammonia. The fluid combination of ammonia obtained in the scrubbers differs in composition and in strength from the true ammoniacal liquor, but it may be analysed in the same manner.

Ammoniacal Liquor as a Washing Fluid.

The ammoniacal liquor itself is extensively used as a washing fluid, after undergoing a slight purification for the removal of the sulphur and cyanogen compounds, which form salts with some portions of the ammonia. The hydro-sulphuric acid may first be removed by means of peroxide of iron or manganese, and slaked lime afterwards added to the liquid, which is then submitted to distillation. The resulting product is an impure solution of ammonia in water, known as washing fluid."

Sulphate of Ammonia.

"In the manufacture of sulphate of ammonia, the ammoniacal liquor is saturated with sulphuric acid, and evaporated in leaden vessels until it is about to crystallize, when it is run out into appropriate vessels; another plan is to distil the ammoniacal liquor, and pass the vapours through sulphuric acid until the sulphate of ammonia precipitates of itself from the boiling hot saturated solution. By the first plan, the whole of the ammonia is secured in the form of sulphate, for even the muriate of ammonia in the liquor is decomposed. This process is, however, slow and costly in fuel, and wear and tear; the salt produced also contains a double quantity of water, and is of a dirty, objectionable colour. In the second process, the ammonia combined with the muriatic acid remains in the still, and is either lost, or requires another

operation for its extraction; but the resulting sulphate contains only one equivalent of water, is very pure, and the wear and tear of the apparatus is trifling. The adoption of Coffey's alcohol column to this manufacture gives much greater facility and perfection of operating than previously."

Muriate of Ammonia.

"In making muriate of ammonia, the ammoniacal liquor is saturated either before or after distillation with muriatic acid, and it is evaporated in the usual manner, so as to obtain crystals, which are subsequently sublimed and converted into sal-ammoniac; or it is made by the reciprocal decomposition of sulphate of ammonia and common salt in solution, in preference to the old plan of effecting the same double decomposition by exposing the mixture of salts to a subliming heat in iron pots, lined with brickwork, and covered with domes of lead, there being in either case a residuary product of sulphate of soda."

Uses of the Residual Products of Gas Making.

The following observations by Dr. Lyon Playfair, in a Lecture delivered before the Society of Arts, in January, 1852, deserve to be quoted, as showing the various purposes to which the residual products from coal gas may be applied :—

The waste and badly-smelling products of gas making appear almost too bad and fetid for utilization, and yet every one of them, chemistry, in its thriftiness, has made almost indispensable to human progress. The badly-smelling tar yields benzole, an ethereal body, of great solvent powers, well adapted for preparing varnishes—used largely for making oil of bitter almonds—of value for removing grease spots, and for cleansing soiled white kid gloves. The same tar gives naphtha, so important as a solvent of india-rubber and gutta-percha. Coal tar furnishes the chief ingredient of printer's ink, in the form of lamp-black; it substitutes asphalte for pavements; it forms a charcoal, when mixed with red-hot clay, that acts as a powerful disinfectant. When the tar is mixed with the coal-dust formerly wasted in mining operations, it forms, by pressure, an excellent and compact artificial fuel. The water condensed with the tar contains much ammonia, readily convertible into sulphate of ammonia, a salt now recognized as being of great importance to agriculture, and employed in many of the arts. Cyanides are also present amongst the products of distillation, and these are readily converted into the beautiful colour known as Prussian blue. The naphthaline, an enemy to the gas manufacturer, by choking the pipes, may be made into a beautiful red colouring matter, closely resembling that from madder;

this, by its transformation, promises an important, though hitherto not yet realized, useful product. Coal, when distilled at a lower temperature than that required to form gas, produces an oil containing paraffine, largely used as an anti-frictional oil for light machinery.

Table showing the maximum cost of Gas per 1,000 cubic feet, made from Newcastle Coal costing from 10s. to 50s. per ton, and including wear and tear, depreciation, and interest on outlay at 5 per cent.

Number of Lights.	Coal at 10s. per ton.		Coal at 15s. per ton.		Coal at 20s. per ton.		Coal at 25s. per ton.		Coal at 30s. per ton.		Coal at 35s. per ton.		Coal at 40s. per ton.		Coal at 45s. per ton.		Coal at 50s. per ton.	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
50	4	4½	5	0	5	7½	6	2½	6	9	7	3½	7	11	8	6½	9	1½
100	3	4½	3	11	4	6	5	0½	5	7½	6	2	6	8½	7	3½	7	10
200	2	4	2	9	3	1½	3	6	3	10	4	2	4	7	5	0	5	5
300	2	1	2	6	2	11	3	4	3	9	4	1½	4	5	4	10	5	3
400	2	1	2	5½	2	10½	3	3	3	8	4	0	4	4½	4	9	5	2
500	2	0½	2	5	2	10	3	2	3	7	3	11½	4	4	4	8½	5	1
800	1	8	2	0	2	4	2	9	3	2	3	6	3	10½	4	3	4	8
1200	1	7	1	11½	2	3½	2	8½	3	1	3	5	3	10	4	2½	4	7
1600	1	5	1	10	2	2	2	6	2	11	3	3	3	8	4	0	4	5
2000	1	4	1	8½	2	1	2	5½	2	10	3	2	3	6½	3	11	4	3½
3000	1	3½	1	8	2	0	2	4	2	8½	3	0	3	3	3	8½	4	1

FORMS FOR BOOKS AND ABSTRACTS.

List of Books required.

The books necessary for recording the operations, general business, and monetary transactions, of a gas company, will, as a matter of course, depend, in a great measure, on the size and magnitude of the works. The following is a list of those which will generally be found sufficient for the conduct of the larger description of works to which these pages are devoted :—

Carbonisation Book.
Men's Time Book.
Goods Delivered Book.
Goods Received Book.
Goods Wanted Book.
Meter Book.
Cash Book.
Consumers' Ledger.
General Ledger.

Gas Consumers' Book.
Day Book or Journal.
Wages Book.
Complaint Book.
Stock Book.
Public Lamp Book.
Invoice Book.
Check Books.

W. C. Holmes & Co.,

In addition to these there will be, of course, the Share and Dividend Books.

Carbonisation Book.

The Carbonisation Book should be ruled on one side of the leaf only, and in the manner shown in Form No. 1—the vertical lines in red ink, and the longitudinal ones to be faint blue; the ruling on one side of the leaf applies only to this book, but the respective colours of the lines will be the same in all. The book should be of the size of the form given, or about eleven inches by eighteen inches. The mode of filling up the various columns will be sufficiently explained by the headings; on the line opposite "Brought forward," and under the column headed, "Register of Meter," should be put down the index of the meter as it stood on the last day of the previous month.

Men's Time Book.

The Men's Time Book (see Form No. 2) will show the amount of labour expended in each department, including carbonising, purification, lighting and extinguishing lamps, putting in new services and meters, repairing mains, &c.; and the cost can consequently be easily arrived at. The book should be about eleven inches wide, and of a length equal to about 1½ times the width; a page should be devoted to each workman, and the ruling and heading should be as shown in form.

Goods Delivered, &c. Books.

The Goods Delivered, Goods Received, and Goods Wanted books, require no explanation; they are simply ordinary day books, for the use of the manager. The Goods Wanted Book, as its name implies, is intended for the purpose of noting down any material which may be required; each entry should give the date of the entry, and when and where ordered.

Meter Book.

The Meter Book, Form No. 3, is for the use of the manager or inspector, when going round to take the register of the consumers' meters, and should therefore be of a convenient size for that purpose.

Cash Book, &c.

The Cash Book, Day Book or Journal, Consumers' Ledger, and General Ledger, need no explanation; they will be, of course, kept by the collector, and in no wise differ from those kept in any other business; they should be on the system of Double Entry.

Huddersfield and London.

Gas Consumers' Book. The Gas Consumers' Book, Form No. 4, embodies the results of the inspection of the meters, taken from the Meter Book, with the price and amount due. The book should be ruled and headed as shown, and of the width of the form, or 11 inches; the length to be about 1½ times the width.

Wages Book. The Wages Book should be ruled and headed as follows:

Form No. 5.

Name of Workman.	Occupation.	Time.	Rate of Wages.	Amount.		
		Days.		£	s.	d.

Complaint Book. The Complaint Book is for the purpose of noting down any complaints which may be made by the consumers, or public authorities, as to insufficient or non-supply of gas, leakage, &c., and should state the date when the complaint was made, and also when it was attended to; a simple memorandum book or diary, therefore, is all that is required.

Stock Taking. The stock of material, as meters, pipes, fittings, tools, coal, coke, breeze, &c., should be taken every year—say at Midsummer, as being most convenient. It should be entered in a book, kept for that purpose. A suitable form for it will be as follows:—

Form No. 6.

Stock Book.

Name of Article.	Weight.				Price.	Amount.			Total Amount.		
	tons.	cwts.	qrs.	lbs.		£	s.	d.	£	s.	d.

Public Lamp Book. The Public Lamp Book should contain a list of all the public lamps, and where they are situated; also the number of the lamp,

if numbers are attached to them, as is frequently the case, and much to be commended; the lamps to which meters are fixed, if any, should be noted, and repairs, &c.

Invoice Book. The Invoice Book is simply a strongly bound book, with brown paper leaves, well guarded, paged, and furnished with an index; into this all invoices should be pasted by one edge, folded, and the name and amount written on the back for easy reference.

Check Books. The collector should also have check books, as per forms No. 7 and No. 8. No. 7 Check Book, as will be seen, is required for the accounts of the consumers. No. 8 Check Book is for the purpose of giving orders on the manager or the man in charge at the time at the works, to supply coke, tar, or any other material; and it should be a rule strictly adhered to, that no material of any kinds hould be sold or disposed of without an order of this kind from the collector, to whom all money should, of course, be payable.

Forms for Working Abstracts, &c. When the works are leased, or the proprietors live at some distance from the place, or in cases where the company may appoint a consulting engineer, it will be necessary for the satisfaction of the lessees, proprietors, or engineer that the working and general accounts should be sent to them at certain given times for examination. For this purpose, abstracts from the books, containing the working details and other information required, must be made out. The following is a list of the abstracts which will be required, and a number of forms for the assistance of the manager and collector are also appended :—

No.	9	*Working Account*	*To be sent weekly*
„	10	*Stock Account*	*do.*
„	11	*Goods Delivered*	*do.*
„	12	*Goods Received*	*do.*
„	13	*Goods Wanted*	*do.*
„	14	*List of New Services and Meters put in*	*do.*
„	15	*Cash Account*	*Monthly or Quarterly*
„	16	*Wages Account*	*do.*
„	17	*Consumers' Account*	*do.*
„	18	*Dr. and Cr. Account*	*do.*
„	19	*Summary of Gas Produced and Consumed*	*do.*

Huddersfield and London.

Those sent weekly would be supplied by the manager, and may be all comprised on one sheet of a convenient size; or separate, if more convenient. Those sent monthly or quarterly would be furnished by the collector.

The Working Account is an abstract of the Carbonisation Book; the Stock Account shows the quantity of coal, coke, lime, &c., in stock; the Materials Sold or Goods Delivered Account, Goods Received, Cash and Wages Accounts, need no comment; the list of new services, &c., will indicate any progress which may be made; the Dr. and Cr. Account shows the amount owing to and by the company, proprietors, or lessee, and the details; the Summary of Gas Produced and Consumed, gives the amount of leakage or gas unaccounted for.

These loose forms should be printed on thin paper for transmission by post.

W. C. Holmes & Co., Huddersfield and London.

Carb

ne Account.	
ed.	Used.
.	Cwts.

No. 2 FORM.
Gas Works. Men's Time Book.

Date.	Description of Work.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Total.
		Hours.	Hours.	Hours.	Hours.	Hours.	Hours.	Hours.	Hours.

No. 3 FORM.
Gas Works. Meter Book.

Name of Consumer.	Residence.	Number of Meter.	Size of Meter.	Wet or Dry.	Maker's Name.	To whom belonging.	Register of Meter on the previous Month.	Present Register of Meter.	Gas Consumed.
							Cubic feet.	Cubic feet.	Cubic feet.

No. 4 FORM.

Gas Works. Consumers' Day Book, ____________ 18__

Name of Consumer.	Number of Meter.	Size of Meter.	Wet or Dry.	Maker's Name.	To whom belonging.	Register of Meter on the previous Month.	Present Register of Meter.	Gas Consumed.	Price per 1000 cubic feet.	Amount due for Gas.	Arrears.	Rental of Meter.	Rental of Fittings	Total Amount.
						Cubic feet.	Cubic feet.	Cubic feet.	s. d.	£ s. d.	£ s. d.	s. d.	s. d.	£ s. d.

FORM No. 7.

*No.*______ 18______

Mr.________________

Register of Meter . ______

Ditto . . . ______

Gas consumed . . ______

at

Rental of Meter .

Arrears . . .

______

______

*No.*______ 18______

Mr.________________

To the________________Gas Light and Coke Company.

		£	s.	d.
Register of Meter . . .	______			
Ditto, ditto	______			
Gas consumed at . .				
Rental of Meter				
Arrears				

FORM No. 8.

*No.*______ 18______

Mr.__________________

*No.*______ 18______

Deliver to Mr.__________________

*Signed*____________________________

FORM No. 9.

____________ Gas Works. Working Account for the Week ending ____________ 18___.

Date.	Day of the Week.	Retorts in use.		Charges.		Register of Meter.	Cubic feet of Gas produced.	Pressure on Mains at Works.		Street Lamps burning.		Gas in Holders at 7 o'clock a.m.	REMARKS.
		Clay.	Iron.	Number.	Duration.			Night.	Day.	Number.	No. of Hours burning		
					Hours.	Cubic feet.	Cubic feet.	Inches.	Inches.			Cubic feet.	
	Brought forward.												
	Monday												
	Tuesday												
	Wednesday ...												
	Thursday												
	Friday												
	Saturday												
	Sunday												
	Total												

FORM No. 10.

Stock Account for the Week ending ____________ 18___,

Material.	In Stock as per preceding return.	Received.	Produced.	Total.	Used for producing Gas.	Used for Fuel.	Sold.	Used for other purposes.	Total.	Nett total for the week ending .
Coal										
Coke										
Tar										
Lime										

FORM No. 11.

Materials sold during the Week ending____________18____.

Coke.	Tar.	Breeze.	Ammoniacal Liquor.	Spent Lime.	Other Materials.

FORM No. 12.

GOODS RECEIVED.	
Date.	

FORM No. 13.

GOODS WANTED.	
Date.	

FORM No. 14.

List of New Services and Meters put in during the Week ending____________18____

Name of Consumer.	Size of Service Pipe.	Length of Service Pipe.	Other Material used.	Size of Meter.	Wet or Dry.	Number of Meter.	Maker's Name.	To whom belonging.	Size of Main to which service is attached.	Labour.

FORM No. 15.

________GAS WORKS. *Cash Account for the Month ending________18__*

Dr. Cr.

Date.			Foilo.	£	s.	d.	£	s.	d.	Date.			Folio.	£	s.	d.	£	s.	d.
		Balance brought forward—										Balance brought forward—							

FORM No. 16.

________GAS WORKS. *Wages Account for the Month ending________18__*

Name of Workman.	Occupation.	Time.	Rate of Wages.	Amount.	Name of Workman.	Occupation.	Time.	Rate of Wages.	Amount.
		Days.		£ s. d.			Days.		£ s. d.

FORM No. 17.

______GAS WORKS. *List of Gas Consumers for the Month ending*________*18*_

Name of Consumer.	Gas Consumed.	Price per 1000 cubic feet.	Amount	Rental of Meter.	Rental of Fittings	Total Amount due.	Name of Consumer.	Gas Consumed.	Price per 1000 cubic feet.	Amount	Rental of Meter.	Rental of Fittings	Total Amount due.
	Cubic feet.	s. d.	£ s. d.	s. d.	s. d.	£ s. d.		Cubic feet.	s. d.	£ s. d.	s. d.	s. d.	£ s. d.

FORM No. 18.

Gas Works. Dr. and Cr. Account for the Month ending ______ 18___.

Dr. | Cr.

Date.			Folio.	£	s.	d.	£	s.	d.	Date.		Folio.		£	s.	d.	£	s.	d.

FORM No. 19.

Gas Works. Summary of Gas produced and Consumed for the Month ending ______ 18___.

	Cubic feet.		Cubic feet.
Gas in Holders		Public Lamps	
Gas produced as per Station Meter .		Private Consumers	
		Gas consumed on Works . . .	
		Gas in Holders	
		Gas unaccounted for . . .	

CONSTITUENTS OF COAL GAS, &c.

"The substances which enter into the composition of coal gas, or are concerned in its generation and combustion, are the following:—

Oxygen	Carbonic Acid	Olefiant Gas	Sulphuretted Hydrogen
Hydrogen	Water	Hydro-Carbons	Cyanogen
Nitrogen	Ammonia	Sulphur	
Carbon	Light Carburetted Hydrogen	Bisulphuret of Carbon	
Carbonic Oxide			

Oxygen. "This element exists in the free state as a colourless, invisible, and inodorous gas, very sparingly soluble in water, or which has hitherto resisted all attempts to liquify it by cold and pressure. In this condition it is evolved from the leaves of plants, under the influence of light, and constitutes about one-fifth of the bulk of our atmosphere. By far the largest amount of oxygen, however, exists in combination with other elements; thus, eight out of every nine tons of water are pure oxygen, and it forms at least one-third of the total weight of the mineral crust of our globe. It is, therefore, the most abundant of all elements. Oxygen gas is heavier than atmospheric air; 100 cubic inches at 60° Fahr. and 30 inches barometric pressure weighing 34·193 grains; whilst 100 cubic inches of air weigh only 31·0117 grains. Since atmospheric air is taken as unity when comparing the density of gases, the specific gravity of oxygen is 1·1026. It eminently supports combustion—all combustible bodies, when introduced into it, burning much more vividly than in common air; indeed, the property of supporting combustion, which common air possesses, is owing to the presence of this gas in our atmosphere.

"The union of oxygen with other elements is always attended by an elevation of temperature. When the union is very slow, as in the rusting of iron, the heat developed cannot be appreciated; but when combination is rapidly effected, it is attended with the phenomenon of light as well as heat, as in ordinary combustion.

"It was formerly thought that the heat developed during combustion was always proportionate to the quantity of oxygen consumed; but recent experiments have not confirmed this opinion. We are indebted to Berthier for an expeditious process for ascertaining the value of a combustible founded on this fact. He mixes the substance to be tested with several times its weight of oxide of lead (litharge) and exposes the mixture in a crucible to a heat sufficient to fuse it. Oxide of lead is composed of oxygen and lead in the proportion of 8 parts by weight of the former to 104 of the latter. At a red heat the combustible matter seizes upon the oxygen, and reduces the lead to a metallic state. This melts, and collects in the form of a button at the bottom of the crucible. As the proportions in which bodies unite are always uniform, it is evident that for every portion of oxygen consumed a certain portion of lead will be reduced, so that the effective combustible matter in the compound examined will be in due proportion to the weight of the button of lead. This process is not quite free from objections, but sufficiently so for many practical purposes.

"Oxygen is usually a constituent of coal gas, as supplied to the consumer, owing to unavoidable leakages and the introduction of atmospheric air into the retorts and purifiers when these vessels are opened. Its presence is highly injurious to the illuminating power of the gas, and as there are no practical means of removing it from the gas, its introduction ought to be guarded against as much as possible.

Hydrogen.

"This element is, like oxygen in a free state, a colourless, invisible, and inodorous gas, scarcely soluble in water. It is very rarely met with in nature uncombined, but free hydrogen has lately been detected in the gases which issue from volcanoes. In combination, it constitutes one-ninth of the total weight of the waters of our globe, and also enters largely into the composition of animals and vegetables, and substances derived from them, as oils, peat, coal, and bitumen.

"Hydrogen gas is generated in abundance, nearly pure, when steam is passed over iron, zinc, and several other metals in a fine

state of division, at a full red heat, mixed with carbonic oxide and carbonic acid gases; it is also generated in a large quantity when steam is passed over charcoal, coke, or other carbonaceous substances at a red heat. In all these cases the watery vapour is decomposed—its hydrogen being liberated whilst its oxygen unites with the metal or carbon, forming in the first case a solid non-volatile oxide, which encrusts the pure metal, and soon stops further action; in the second case, a gaseous oxide of carbon is generated, and passes off along with the hydrogen, thus leaving the carbon freely exposed to the further action of the watery vapour. That portion of the steam which is converted into hydrogen and carbonic oxide, yields its own volume of each of these gases; and that portion which forms hydrogen and carbonic acid affords its own volume of hydrogen, and half its own volume of carbonic acid. The amount of watery vapour which undergoes the latter decomposition decreases as the temperature at which the operation is conducted increases. At a white heat, scarcely a trace of carbonic acid is produced. Hydrogen is the lightest of all known bodies, its specific gravity being only ·0691; 100 cubic inches at 60° Fahr. and 30 inches barometric pressure weigh only 2·1371 grains. It has a powerful affinity for oxygen, but developes scarcely any light during combustion. When, however, solid substances, such as lime, magnesia, platinum, are held in the flame of hydrogen, considerable light is emitted. Burnt in air or oxygen gas, it is entirely converted into watery vapour, which condenses upon cold surfaces held above the flame. One cubic foot of hydrogen at 60° Fahr. and 30 inches barometric pressure consumes half a cubic foot of oxygen, generates one cubic foot of watery vapour, and affords heat capable of raising the temperature of 1 lb. 13 oz. of water from 32° to 212° Fahr.; or that of a room containing 2,500 cubic feet of air from 60° to 66·4° Fahr.

Water

"Is composed of two volumes of hydrogen, and one volume of oxygen, or one part by weight of hydrogen and eight parts of oxygen. Oxygen and hydrogen, though mixed in the proper proportion for combining, do not unite until the temperature of a

portion of the mixture has been raised to redness; they then unite with a loud explosion. When brought together gradually and inflamed, as when a jet of oxygen is admitted into a jar of hydrogen, or *vice versâ*, they burn quietly, with a non-luminous but intensely hot flame, and produce pure water. The general properties of water are too well known to require description. It is always produced by the decomposition of coal by heat. This arises from two causes: the presence of hygrometric water in the coals, and likewise from its elements forming a part of their composition. The former portion is the first product which passes from the retorts; the second only comes over when the actual decomposition of the coal has commenced. This water is condensed, and carried into the tar well, where it holds in solution many of the more soluble products of the distillation. Besides its well known solvent action upon solids, water possesses the property of absorbing or desolving gases; and a knowledge of its relative solvent action upon the various gases is of great importance to the gas manufacturer.

"The following table gives the number of volumes of various gases which 100 volumes of water at 60° Fahr., and 30 inches barometric pressure can absorb:—

Ammonia	7800 volumes	Carbonic Oxide	1.56 volumes.
Sulphurous Acid	3300 ,,	Nitrogen	1·56 ,,
Sulphuretted Hydogen	253 ,,	Hydrogen	1·56 ,,
Carbonic Acid	100 ,,	Light Carburetted Hydrogen	1·60 ,,
Olefiant Gas	12·5 ,,		
Oxygen	3·7 ,,		

Illuminating Hydro-carbons, not determined, but probably more soluble than olefiant gas.

"When water has been saturated with one gas, and is exposed to the influence of a second, it usually allows a portion of the first to escape, whilst it absorbs an equivalent quantity of the second. In this way, a small portion of a difficultly soluble gas can expel a large volume of an easily soluble one, a familiar instance of which we have in the case of a glass of champagne, which has ceased to sparkle, but which is again brought into a state of brisk effervescence by a smart blow upon the mouth of the glass with the concave palm of the hand. Under the pressure thus

produced, the wine absorbs a small quantity of atmospheric air, which then expels a considerable amount of the more soluble carbonic acid.

Nitrogen

"Exists in a free state in the atmosphere, and enters into the composition of a large number of animal and vegetable substances. All descriptions of coal contain small quantities of this element. When nitrogen is eliminated from combination in contact with oxygen, it usually takes the form of nitrous or nitric acid; whilst in contact with an excess of hydrogen, it generates ammonia. It is in this latter form that it is eliminated from coal in the process of gas generation. Nitrogen is a colourless, inodorous, and tasteless gas, of specific gravity 0·976. It is incombustible under ordinary circumstances, and instantaneously extinguishes burning bodies. Under certain conditions, however, nitrogen does undergo combustion, as when it is exposed to a very intense heat in the presence of oxygen. This occurs, for instance, when a small quantity of nitrogen is added to a mixture of hydrogen, with a somewhat larger proportion of oxygen than is requisite to form water, and the mixture is then ignited. A loud explosion takes place, and a considerable quantity of nitric acid is formed, owing to combustion of the nitrogen, or, in other words, its union with oxygen gas. This formation of nitric acid no doubt occurs also to a limited extent during the burning of coal gas; and as the temperature required to form nitric acid is very high, the greater the volume of gas consumed from one burner in a given time, the greater will be the relative quantity of nitric acid produced. The formation of such a corrosive material as nitric acid under these circumstances shows the importance of preventing the admixture of the products of the combustion of coal gas with the atmosphere of the apartments in which it is consumed.

"The presence of free nitrogen in coal gas is probably entirely due to the admission of atmospheric air, and not to the elimination of the nitrogen contained in the coal; for the latter appears to be evolved only in combination with hydrogen as ammonia. As nitrogen is incombustible, it is not only a useless ingredient

in coal gas, but owing to its abstracting heat from the flame of such gas, it causes a diminution of light, and is thus decidedly injurious.

Ammonia

"Is formed during the distillation of coal, and of all organic substances containing nitrogen. In such distillations the nitrogen unites with hydrogen in the proportion of 14 to 3, the formula being NH_3, and ammonia is the result. It is a colourless gas, specific gravity ·5898, very pungent, acting strongly on the nose and eyes when respired. It dissolves in a very small portion of water, one volume of this liquid taking up about 780 volumes of the gas, and forming a liquid possessed of similar properties, and sold in the shops under the name of spirits of hartshorn. Ammonia is strongly alkaline, uniting readily with all the acids, and forming salts which sublime at a comparatively low temperature. It also unites with sulphuretted hydrogen, producing a highly offensive volatile substance. Gaseous ammonia, unmixed with other gases, is incombustible; but when present in coal gas, it burns with the latter, and is converted principally into nitric acid. The greater part of the ammonia produced in the manufacture of gas is found in the liquor which floats on the surface of the bituminous substances in the tar well; it is collected and sold to the manufacturers of ammoniacal salts, or otherwise disposed of.

Carbon

"Is well known under the form of diamond, charcoal, lamp-black, and coke, all of which substances are carbon mixed with small and variable quantities of foreign matters. As this element is the basis of illuminating gases, a knowledge of its chemical properties is of great importance. Carbon does not combine with oxygen at ordinary temperatures, but does so with great energy on the application of a strong heat, emitting at the same time intense light, which increases in brilliancy as the temperature rises. It is not, however, the particles of carbon which are actually undergoing combustion that emit this light, but those which are heated to incandescence or are suspended for an instant in the flame before they come in contact with the atmospheric oxygen. Carbon exhibits no tendency to unite with hydrogen at any temperature unless these elements are under the influence of the vital force, as

in the bodies of animals and tissues of plants. Under this influence, however, they unite in almost innumerable proportions, forming a most extensive and highly important series of bodies known as hydro-carbons. Carbon unites with oxygen in two proportions, forming carbonic oxide and carbonic acid gases.

Carbonic Oxide

"Is the lowest state of oxidation of carbon; it contains one equivalent or 6 parts of carbon, and one equivalent or 8 parts of oxygen. This gas is formed when carbon is consumed in a limited quantity of air or oxygen, and is also generated when steam is passed over ignited coke or charcoal, or when coal tar and steam meet in a red-hot vessel. It is always a constituent of coal gas. It is a colourless and inodorous gas, rather lighter than atmospheric air, and having exactly the specific gravity of olefiant gas—·9727; it is very sparely soluble in water, but is very soluble in an ammoniacal solution of subchloride of copper. It is inflammable, burning with a beautiful blue flame almost devoid of light; the product of its combustion is carbonic acid. One cubic foot at 60° Fahr. and 30 inches pressure, consumes during combustion half a cubic foot of oxygen, generates one cubic foot of carbonic acid, and yields heat capable of raising 1 lb. 14 oz. of water from 32° to 212° Fahr., or causing a rise of temperature from 60° to 66·6° Fahr. in a room containing 2,500 cubic feet of air.

Carbonic Acid

"Is always generated when carbon is burnt in an excess of air or oxygen; it is formed during fermentation, putrefaction, and decay, and in small quantity during the earlier stages of the distillation of coal; it is also a product of the decomposition of water by carbon at a red heat.

"Carbonic acid differs strikingly from carbonic oxide in its properties, though it only differs in constitution by containing double the quantity of oxygen: the latter containing 6 parts of carbon and 8 of oxygen; whilst the former contains 6 parts of carbon and 16 of oxygen. Carbonic acid is pungent, acidulous, and soluble in an equal bulk of water, to which it communicates that briskness which we so much admire in soda water. It is considerably heavier than atmospheric air, its specific gravity being 1·524. This gas is uninflammable, and cannot support

combustion, or animal life; its acid properties are not strongly developed, but it unites readily with alkaline bases, forming carbonates. It is upon this property that the removal of carbonic acid from coal-gas depends. On passing coal gas containing this acid through slaked lime in fine powder, or through milk of lime, the whole of the carbonic acid disappears, having united with the lime. A layer of lime one inch thick, in a dry lime purifier, will not allow a trace of the carbonic acid to pass through it. The presence of a small percentage of carbonic acid in gas will cause a considerable loss of light, 1 per cent. diminishing the illuminating power of coal gas to the extent of about 6 per cent.

Light Carburetted Hydrogen,

"Which is also known under the names of marsh gas and hydride of methyl, is always a constituent of coal gas; it is also a natural product of the slow decomposition of coal, and of putrefaction in general. Thus it occurs in large quantities in coal strata, and bubbles up from stagnant pools and ditches which contain putrefying organic remains. As thus generated, it is mixed with small quantities of carbonic acid and nitrogen; it can, however, be artificially prepared perfectly pure, but the processes need not be described here. When pure it is colourless, tasteless, and inodorous; it is neutral to test papers, and nearly insoluble in water. Its specific gravity is ·5594, and 100 cubic inches at 60° Fahr. and 30 inches barometric pressure weigh 17·4166 grains. It does not support combustion or respiration, but is inflammable, burning with a blue or slightly yellow flame, yielding scarcely any light; mixed with a due proportion of atmospheric air or oxygen and ignited, it explodes with great violence; the products of its combustion are water and carbonic acid. One cubic foot at 60° Fahr. and 30 inches pressure consumes two cubic feet of oxygen, and generates one cubic foot of carbonic acid; during combustion it yields heat capable of raising the temperature of 5 lbs. 14 oz. of water from 32° to 212° Fahr., or that of a room containing 2,500 cubic feet of air from 60° to 80·8° Fahr. When it is exposed to a white heat it is slowly decomposed, depositing carbon, and yielding twice its volume of hydrogen.

Olefiant Gas

"Is rarely met with in nature, but as it is generated in great

abundance when coals or other bituminous matters are exposed to high temperatures, it might be expected to occur when any coal-bearing strata are exposed to volcanic heat, and has, in fact, been occasionally met with as a natural product under these circumstances. Olefiant gas, nearly pure, can be prepared artificially by heating in a suitable glass retort a mixture of one part by weight of alcohol and 5 or 6 parts of concentrated sulphuric acid; the gas should be passed through a solution of caustic soda, to remove the sulphurous acid and carbonic acid with which it is generally contaminated. Olefiant gas is colourless, and possesses a peculiar and somewhat unpleasant odour ; its density is ·9784, and 100 cubic inches at 60° Fahr. and 30 inches pressure weigh 30·3418 grains. It consists of 2 volumes of carbon vapour and 4 volumes of hydrogen. It is inflammable, but does not support combustion; when inflamed, as it issues from a jet into the atmosphere, it burns with a large white flame, emitting a very brilliant light without smoke. During its combustion it consumes 3 times its volume of oxygen, and generates twice its volume of carbonic acid. Passed through a red-hot tube, or otherwise exposed to a full red heat, it is rapidly decomposed, carbon being deposited, and hydrogen and probably light carburetted hydrogen produced; by being thus heated, its illuminating power is entirely destroyed. It is probably always present in gas, and contributes greatly to its illuminating power.

Gaseous Hydro-carbons.

"The manufacture of gas for illuminating purposes has for its object the production of the largest amount of gaseous hydro-carbons from a given weight of material. The only ones known which have been proved to be present in coal gas are light carburetted hydrogen and olefiant gas; but there are strong reasons for believing that, in addition to a host of unknown ones, at least two others exist in gas, whose composition and properties have been investigated—propylene and butylene. The first is produced artificially by passing the vapour of fusel oil through a red-hot tube; and the second, which is present in coal gas, is generated during the electric decomposition of valerate of potash. Both these gases are colourless, possess a slight ethereal odour, and

burn with a brilliant white flame, having an illuminating power much greater than that of olefiant gas; they are rapidly decomposed when subjected to a red heat. Propylene consists of 3 volumes of carbon vapour and 6 volumes of hydrogen, the 9 volumes being condensed to two; it hence contains 50 per cent. more carbon in a given volume than olefiant gas. Its specific gravity is 1·4511. Butylene consists of 4 volumes of carbon vapour and 8 volumes of hydrogen, the 12 volumes being condensed to two; it therefore contains double the amount of carbon present in an equal volume of olefiant gas. Its specific gravity is 1·9348. As the illuminating power of these gases is directly proportionate to the amount of carbon contained in a given volume, the illuminating values of olefiant gas, propylene, and butylene must be as 1, 1·5, 2.

Liquid hydro-carbons

"Make up the great bulk of the tar produced in gas making, and compose the coal naphtha and coal oil obtained by its distillation. The more volatile portion of them diffuse their vapour into the gas itself, and thus contribute considerably to its illuminating power. This they do by reason of the large quantity of carbon which a given volume of their vapour contains. Their number is great, but a few only have been investigated.

Benzole.

"This remarkable hydro-carbon is contained in the portion of crude coal tar naphtha which distils over between the temperatures of 176° and 194°. It is a colourless and transparent liquid, specific gravity, 0·85, having a pleasant ethereal smell, and boiling at 177°; at 32° it solidifies to a white crystalline mass, like camphor. It is extremely inflammable, its vapour readily taking fire on the approach of flame; in fact, so much vapour is formed at ordinary temperatures, that a current of hydrogen, or even of atmospheric air passed through it, and afterwards ignited at a jet, burns with a white flame highly luminous. It acts as a powerful solvent for many substances; thus it readily dissolves many resins, mastic, camphor, wax, fatty and essential oils, caoutchouc, and gutta-percha; it dissolves shellac sparingly, but mixes in equal bulks with a saturated solution of lac in wood spirit, or alcohol. Treated with nitric acid, benzole is converted into nitro-benzole, a liquid possessing a very agreeable odour

similar to that of oil of bitter almonds, and which is now very extensively used as a substitute for that essential oil in perfumery.

Carbolic Acid. "This singular compound is contained in that portion of coal oil which boils between 300° and 400°. If this portion of oil be agitated with twice its volume of soda lye, the aqueous solution, on the addition of an acid, yields carbolic acid as a heavy oil; it is purified by being rectified with a small quantity of solid potash. Carbolic acid has the appearance of a colourless, oily liquid, it has a burning taste, and a penetrating smell like creosote; its specific gravity is about 1·062. It is of interest from its close chemical relation to indigo, and from its powerful antiseptic and preservative properties, which are quite equal to those of creosote, for which liquid it could probably be in most cases substituted.

Eupion "Is a liquid prepared from cannel coal tar by repeated treatment with concentrated oil of vitriol, and subsequent rectification from soda lye; it possesses a pleasant fruity smell, and might probably be used with advantage as a solvent for gums and resins, and as a substitute for chloroform.

Solid Hydro-carbons. Paraffine. "Paraffine is a white solid substance, resembling wax. It melts at 110° and distils without decomposition at a high temperature; its specific gravity is ·870. When made into candles, it burns with a clear white light, free from smoke, and fully equal to the best white wax. Dissolved in the less volatile portions of the Boghead coal oil, it forms the so-called paraffine oil, which possesses lubricating properties in no wise inferior to those of sperm oil, for which it is now extensively substituted. Paraffine is contained only in considerable quantity in the tar from Boghead cannel; the latter portions of the heavy oil procured from the distillation of this tar are semi-solid, owing to the large quantity of paraffine crystals which they contain. By straining through a canvas filter, and pressure, the impure paraffine is obtained; it is further purified by treatment with concentrated sulphuric acid.

Naphthaline, Para-naphthaline, Chrysene, and Pyrene "Are white crystalline bodies, much resembling each other in appearance, but differing in volatility and chemical composition. Naphthaline, which is the most volatile, seems to be always present in coal gas, which owes its disagreeable odour principally to

this substance. When the gas charged with naphthaline vapour is allowed to leave the holder at a temperature higher than that of the mains through which it subsequently flows, a portion of the naphthaline is deposited as the gas cools, and the constant additions of this deposit much diminish the bore of the pipes. This would probably be avoided by previously passing the gas over a large surface of coal oil, so as to dissolve the naphthaline. Naphthaline has not yet received any important technical applications, but by being submitted to certain chemical processes it yields chloro-naphthalic acid, a compound possessing nearly the same composition and properties as alizarine, the most valuable colouring principle of the madder root.

Pittacal

"Was found by Reichenbach in the heaviest portions of the oil of tar. The methods for its separation and purification are not yet known; it is, however, said to be a solid of a very fine deep blue colour, like indigo, its polished surface having a golden lustre; it can be fixed on cloth, and would form a most valuable dye-stuff.

Bisulphuret of Carbon

"Is formed whenever sulphur and carbonaceous matter are brought together at a bright red heat; and, therefore, owing to the presence of sulphur in all varieties of coal, its vapour is generally, and probably always, present in coal gas. It is a colourless liquid of a most insupportable odour, resembling garlic; it is very volatile, boiling at 108°. It does not mix with water, but dissolves in alcohol and ether; it is also very soluble in a solution of caustic soda or potash, in methylic, ethylic, or amylic alcohol. It is very inflammable, and generates during combustion much sulphurous acid. On this account its presence in coal-gas is very injurious, and as there is no known means of removing it on a large scale by any method of purification, its non-generation in the process of gas making becomes a problem of great importance. It has been observed that its formation is greatly hindered, if not entirely prevented, by the employment of a somewhat moderate temperature. Although no process for the absorption of bisulphuret of carbon vapour from coal gas is sufficiently cheap for employment on a large scale, yet advantage may be taken of

its solubility in a solution of caustic pota sh, in fusel oil (a bye-pro duct in spirit distilleries), or in methylated spirits of wine, for its removal from the gas supplied to private houses. By passing the gas over a considerable surface of this solution, contained in a small private purifier, the bisulphuret of carbon vapour is completely removed. This vapour can be readily detected in coal gas by a very simple apparatus devised by Mr. L. Thompson. In this instrument, the products of the combustion of a jet of gas are made to pass through a small Liebig's condenser; if the liquid dropping from this condenser strongly reddens blue litmus paper, it is highly probable that bisulphuret of carbon is present. As a decisive test, 50 or 60 drops of the condensed fluid should be collected in a small test tube, and a few drops of pure nitric acid added. On heating this mixture to boiling, over a spirit lamp, and then adding a drop or two of a solution of chloride of barium, the liquid will become more or less milky if bisulphuret of carbon has been present in the gas. The gas must, however, be first tested for sulphuretted hydrogen.

Sulphuretted Hydrogen

"Is formed by the conjunction of hydrogen and sulphur at a red heat; it is hence always an ingredient in crude coal gas, but can be perfectly removed by purification. It can be prepared pure by decomposing proto-sulphuret of iron with dilute sulphuric acid, and collecting the evolved gas at the pneumatic trough or over mercury. It is a colourless gas of very nauseous odour, resembling that of putrid eggs; its specific gravity is 1·1747. It is highly inflammable, burning with a blue flame destitute of light, and generating a large amount of sulphurous acid; it is chiefly this latter circumstance that renders its presence in coal gas objectionable. It is readily absorbed by metallic solutions, oxide of iron and lime, and is easily recognized in gas by the acetate of lead test.

Cyanogen

"Is generated in small quantities during the distillation of coal; it unites immediately with ammonia or with sulphide of ammonium, forming either cyanide of ammonium, or sulpho-cyanide of ammonium, both of which dissolve in the so-called gas liquor. In its pure state it is a colourless gas of a peculiar odour, and is very

poisonous. It is inflammable, burning with a crimson flame. United with hydrogen, it forms hydro-cyanic (prussic) acid, and combined with iron it generates Prussian blue, though the expense of extracting it has been hitherto too great on account of the quantity of cyanogen being too minute."

THE ANALYSIS OF GAS.

"The analysis of gas is rather a complicated undertaking, though a good idea may be formed of its composition by the following process: collect a quantity of gas in a graduated tube over quicksilver; introduce a solution of caustic potash, and agitate it with the gas for some minutes; then allow the tube to stand for a short time, and observe how much carbonic acid has been absorbed. After this is done, pass up a concentrated solution of pyrogallic acid in potash, or, better still, a small quantity of the powdery crystals of pyrogallic acid itself; shake the tube again, and having allowed it to stand for a few minutes, read off the bulk of oxygen that has disappeared; transfer the gas to another tube over water, and by means of a syringe or other contrivance, introduce a small quantity of bromine, or of strong solution of bromine; shake the tube for a minute or so, and observe that the bromine is in sufficient quantity to give the gas an orange-red colour; after the lapse of four or five minutes, pass up a solution of potash, and shake again. In this way the excess of bromine will be absorbed; and, on allowing the tube to stand for a short time, the amount of condensible hydro-carbon may be determined by the loss in bulk. Transfer the gas to another tube, and agitate it with a solution of dichloride of copper in muriatic acid (this is made at once by mixing equal parts of black oxide of copper and recently precipitated copper with muriatic acid). After a few minutes the solution is to be withdrawn, and the gas washed with potash; the loss in bulk indicates the quantity of carbonic oxide present. Lastly, a portion of the residual gas is to be transferred to an

eudiometer, and mixed with about twice its bulk of oxygen, and the mixture is to be fired by the aid of an electric spark. After standing for a few minutes, the loss in bulk is to be observed; a solution of caustic potash is then to be passed up into the gas, and the absorption of carbonic acid noted. This indicates the amount of light carburetted hydrogen present; and then by subtracting twice this volume from the total amount of diminution caused by the detonation, we obtain a number, two-thirds of which represents the hydrogen of the gas. Lastly, the residual gas, from which the portion for the oxygen experiment was taken, is to be mixed with about 4 times its bulk of pure chlorine, and exposed for some hours to daylight, or for a moment or two to sunlight, and then washed with potash—the residue is nitrogen. In this way we may obtain an estimate of the proportions of the chief constituents of coal gas. These, however, vary to the following extent:—

Light Carburetted Hydrogen	forms	35 to 52	per cent.
Hydrogen	"	25 to 52	"
Carbonic Oxide	"	7 to 9	"
Carbonic Acid	"	0 to 4	"
Oxygen	"	0 to 2	"
Nitrogen	"	0 to 8	"
Condensable Hydro-carbons	"	3 to 20	"

Photometer.

"The approximate or commercial value of coal gas is determined in several ways, thus:—

"1st. By means of the photometer.

"The power of light and heat diminishes as we recede from any object that produces it, and the decrease is in proportion to the square of the distance; for example, if we have a certain amount of light at a foot from its source, the intensity will be one-fourth at 2 feet, because the square of 2 is 4; one-ninth at 3 feet ($3 \times 3 - 9$), one-sixteenth at 4 feet ($4 \times 4 - 16$), one-twenty-fifth at 5 feet ($5 \times 5 - 25$), and so on. Upon this law is founded all the methods now employed for estimating the relative value of different illuminating agents. The one which is now generally used is that contrived by Professor Bunsen. It will be noticed, that if a piece of white filtering paper is smeared with melted

wax or spermaceti, it acquires a greasy appearance, and becomes translucent; if this be done so as to leave a spot or disc, about the size of a shilling, untouched in the centre of the paper, we shall find that the apparatus will have the following properties:— When examined by reflected light, that is, with the light on the same side of the paper as the observer is, the disc will look white and the surrounding greasy part, dark; but by altering the condition of things, and looking at the paper by transmitted light, that is, with the light on the other side of the instrument, the disc will appear dark, and the surrounding greasy portion light and translucent. Lastly, if two lights of equal intensity are placed one on each side of the paper, the disc will disappear entirely, for then the light of one side neutralises that of the other, and there is no disposition to produce either effect. Upon this is founded the principle of Bunsen's photometer. This instrument, in its most approved form, consists of a wood rod, exactly 100 inches long from the centres of the sockets at each end; this rod is graduated in accordance with the above laws of the distribution of light, commencing from the centre, in divisions marked each way towards the ends of the rod up to 36, the lower divisions up to 9 being each subdivided into 10 parts, and from 9 to 20 in two parts each. At one end of the rod is an upright pillar, supporting the rod and also a candle holder. The other end of the rod is supported by an experimental meter into which a pillar is inserted, which also conducts the gas to the burner from the meter; this pillar has also a pressure-gauge and two cocks attached, one of which has a micrometer movement, for more readily adjusting the burner. The meter is for the purpose of ascertaining the quantity of gas consumed by the burner per hour, by noting the rate of consumption in one minute. The dial has two circles, an inner and an outer one, and two pointers; the outer circle is divided into 4, and the inner circle into 6, equal parts, and each part is again divided into tenths; the outer circle represents the quantity actually consumed in feet and tenths of a foot, and the inner circle divisions each represent 1·60th of a cubic foot, and 1-600th of a cubic foot. Therefore, one minute's observation of

the inner circle will give the hourly consumption in cubic feet and tenths of a foot, and the same length of observation of both circles the actual consumption. Thus, supposing that the inner circle pointer, when placed opposite the figure 6, which it is usually arranged to do, passes in the space of a minute to the fifth minor division beyond the figure 4, it would read off as a consumption of 4 5-10ths cubic feet per hour, the actual consumption being 4-60ths and 5-600ths of a cubic foot in 1-60th of an hour.

"On the long rod is placed a wood slide with pointer, and having a socket on the top to receive the disc, which is contained in a circular metal frame, and which is protected by a blackened conical screen.

"A governor or regulator is very frequently used for adjusting the pressure of the gas to the burners, in which case it must be arranged that the gas shall pass through it *after* passing through the meter.

"Care must be taken to have the centres of the gas flame, disc, and candle flame in one horizontal line. When the conical screen is used, it is sufficient to suspend a piece of black calico behind each light, but in a room specially prepared for the purpose, the screen may be dispensed with. A room for photometrical purposes should be about 12 feet square; the photometer, &c., should be placed on a table about 10 feet long and 2 feet wide × 3 feet 3 inches high; the walls, ceiling, and table should be coloured a dead black, to prevent reflection of the light; this room must be well ventilated by suitable means which will not interfere with the exclusion of the light.

"The prepared paper is made by coating white blotting paper with sperm, excepting a small spot in the centre.

"The paper is to be observed through the holes in the cone, and the slide moved backwards and forwards along the rod until the neutral position between the lights is found, when the pointer will indicate the illuminating value of the lights which are being tested; the mean of three or four observations, taken alternately on each side of the disc should be taken as the correct value of the lights.

W. C. Holmes & Co.,

"When the candle burns more or less than the standard quantity, the quantity thus consumed should be corrected to the standard, which is 2 grains per minute; for instance, if an argand burner consuming 5 cubic feet per hour gives a light equal to 15 candles at 5-10ths of an inch pressure, the candle consuming at the rate of 2·11 grains per minute, the gas will be equal to 15·82 candles :—

$$\frac{15 \times 2{\cdot}11}{2{\cdot}0} = 15{\cdot}82$$

"It is usual to provide a minute clock, constructed to strike every minute, thus enabling the operator to give his undivided attention to the meter.

"A diversity of opinion exists as to the illuminating standards which should be used. The Parliamentary standard for candles is sperm, six of which weigh one pound, burning at the rate of 120 grains per hour, though there are several objections to its use—the light given by it is too small as compared with that of the gas, and the rate of burning is affected by various circumstances, as vapour surrounding it during combustion, temperature of the room, and differences in manufacture, causing it to burn irregularly; these objections apply also to wax and paraffine, which have been suggested for the same purpose. Whilst, however, the present standard remains in use, and until a better one is provided, care must be exercised to avoid errors as much as possible.

"When about operating, weigh the candle carefully, and before lighting warm the wick and sperm surrounding it, so that it may be lighted fully and at once. When placed in its socket, carefully compare its light with the one against which it is being tested for 10 minutes, making a note of the indications every minute, and then take the average of these indications for the result. The candle must then be extinguished, and re-weighed. In order to decrease the difficulties arising from the variation of the standard candle, the value of the gas should first be ascertained by its means, and where two gases are being compared with each other, by contrasting the two together. This plan also applies when ascertaining the relative economy of different burners.

Huddersfield and London.

"The gas-burner fixed by Act of Parliament is an argand of 16 holes, with a 7-inch chimney, and consuming 5 cubic feet per hour; the quality of the gas, however, is best estimated by consuming it in the burner or jet best suited for its combustion. As a rule, common gas requires larger apertures than cannel for its combustion, and high glasses or chimneys are apt to lower the illuminating power of the former, and increase that of the latter. There is no doubt that, in most cases, a fish-tail or bat's-wing burner will form the best testing burner. The following table shows how the description of burner affects the results arrived at:—

Burner.	Consumption per hour in cubic feet.	Illuminating power.	Illuminating power per cubic foot.
Jet, 5 inches high ...	1·00	1·00	1·00
Small fish-tail	1·98	2·89	1·45
Large fish-tail	2·60	4·00	1·53
Small bat's-wing	3·00	4·40	1·46
Large bat's-wing......	4·60	8·40	1·87
Argand of 40 holes...	4·50	7·84	1·74

"These results were obtained by Dr. Fyfe with cannel gas; and they show that the large bat's-wing produces a flame that, for equal consumption, is nearly twice as powerful as that of the single jet.

2nd. The Chlorine test.

"This test is very much appreciated by Dr. Fyfe. The objection to its use is its inconvenience; for chlorine takes a long time to prepare, and we are never certain of its being pure. Besides which, it is an unpleasant gas to inhale, and produces the most serious injury to the brass and iron work of chemical apparatus. The mode of conducting the experiment is this:—A quantity of gas is to be let up into a graduated tube over water, the tube is then to be covered so as to exclude light, and chlorine is to be passed up into it. After standing for 10 to 15 minutes in the dark, the excess of chlorine is to be absorbed by potash, and the amount of absorption read off. The larger the quantity absorbed, the better the gas. This will range from 3 to 20 per cent.

The matters absorbed by the chlorine are the condensible hydro-carbons, which are the illuminating principles of the gas.

3rd. The Bromine Test. "The reactions of bromine on gas are exactly the same as those of chlorine ; but it has an advantage over the latter, in the circumstance that it is much more manageable, that it is more likely to be pure, and that the admission of light does not affect the results. In manipulating with this body, a graduated tube, called a Cooper's tube, is filled with gas, and then a small quantity of a saturated solution of bromine in water is poured into the shorter leg of the instrument, taking care to use enough to give the gas an orange-red colour. After the mixture has been shaken, the tube is allowed to stand for about 10 minutes, and then the excess of bromine is to be absorbed by means of potash, after which the amount of absorption is noted. As in the last case, this will range from 3 to 20 per cent., according to the quality of the gas.

4th. The Sulphuric Acid Test. "In this test the mode of experimenting is as follows :—The gas is to be collected in a graduated tube over mercury, and then a piece of coke or pumice stone, fastened to a platinum wire, and moistened, or rather saturated with the acid, is to be passed up into the gas; after remaining in contact with it for 10 or 15 minutes the coke is to be withdrawn ; and as a small quantity of sulphurous acid will have been formed by the action of the coke upon the mercury, the gas is to be washed with a little potash, and then the amount of absorption noted. Sulphuric acid does not, however, attack all the hydro-carbons, for it is found that chlorine or bromine will effect a further condensation after the action of the acid. This, with other circumstances, renders the process objectionable."

5th. The Explosion Test. Dr. Henry noticed that there was a direct relation between the value of a gas for illuminating purposes, and the quantity of oxygen required to burn it, or of carbonic acid produced thereby. In fact, as the illuminating power of any gas is dependent on the quantity of carbon contained in a given bulk of it, it follows that the products of its combustion must furnish a sure

indication of its value. This will be manifest from the following table :—

One Volume of	Oxygen required to burn	Carbonic Acid produced.
Marsh Gas (CH^2)	2 volumes	1 volume
Olefiant Gas (C^4H^4)	3 „	2 „
Super-olefiant Gas (C^6H^6).........	4·5 „	3 „
Faraday's Gas (C^8H^8)	6 „	4 „
Bicarburetted Hydrogen (C^6H^3)	7·5 „	6 „

So that, if we mix a known quantity of any gas with about three times its bulk of oxygen, and explode them in an eudiometer by means of electricity, or make them combine by the aid of spongy platinum, the amount of oxygen consumed, and of carbonic acid produced, will indicate the quality of the gas. The best description of coal gas requires 2¼ times its bulk of oxygen for combustion, and gives 1¼ of carbonic acid; the amount of carbonic acid produced is to be determined in the usual way by means of liquor potassæ.

6th. The Specific Gravity Test.

This is founded on the fact that the rich hydro-carbons are much heavier than the poor ones; for example, if a given bulk of light carburetted hydrogen weighs 10 grains, the same bulk of olefiant gas will weigh 17½ grains. Take a glass globe or flask, fitted air-tight to a stop-cock, and exhaust it with great care by means of an air-pump; then let in pure and dry hydrogen, and again exhaust. Do this a third or even a fourth time, so as to get the flask as empty of air as possible; then weigh in a delicate balance and note the amount; pure and dry atmospheric air is now to be admitted, and the flask again weighed. In this manner is ascertained how much of pure dry air at 60° Fahr. and 30 inches barometric pressure it contains. When it is wished to take the specific gravity of any gas, the globe is to be exhausted as before, then filled with the gas and weighed; corrections are to be made for any abnormal difference of temperature or pressure; and then, as the weight of the vessel full of air is to 1, so is the weight of the gas to its specific gravity. In practice it will be found convenient to have a globe with two stop-cocks, one opposite the other; so that after the first exhaustion and weighing, the globe can be

easily filled with gas without the aid of an air-pump, by simply allowing the gas to pass through it for about fifteen minutes. Mr. Wright's apparatus consists of an oiled silk balloon, holding 1,000 cubic inches of gas; and, as coal gas is lighter than air, he determines its specific gravity by ascertaining the number of grains which the balloon will carry up. A book accompanying the apparatus gives the necessary instructions for its management. In conducting experiments of this kind it must be ascertained that the gas does not contain carbonic acid, carbonic oxide, or atmospheric air, or they will give a high specific gravity to the gas, though the illuminating power may be very low.

7th. The Durability Test.

Dr. Fyfe is accustomed to estimate the value of a gas, not only by noting its amount of condensation by chlorine, but also by observing the time that it takes to burn a given bulk of it from a jet of a given size, with a flame of a given height. The jet which he employs has an aperture of 1-33rd of an inch in diameter, and the flame is 4 inches in height. The first he calls the quality test, and the latter the durability. He considers both these tests as absolutely necessary, for, unless both are taken into account, we do not arrive at the true value of the gases. He thinks it possible that two gases may afford by combustion the same amount of light for the same height of flame, but that one may burn away half as fast as the other; and consequently, if no regard is paid to this circumstance, there will be a false estimate of their relative values. His mode of amalgamating these two powers is to multiply the percentage amount of condensation by the durability, or time required to burn a cubic foot; and in this way he obtains a number that may be said to represent the true value of the gas. Suppose that one gas, which he takes as a standard, has a condensation of 4·33 and a durability of 50·5 minutes, these multiplied together make 218·7, which may be called the value of the gas. Another gas has a condensation of 7·55 and a durability of 57 minutes, these multiplied together give a value of 430·3. Now, if we call the standard number of the former 1, that of the second will be 1·95. The following table is constructed on this principle:—

Huddersfield and London.

Gas from	Condensation by Chlorine.	Durability of a cubic foot.	Relative Value.
		Minutes.	
Newcastle Caking Coal	4·33	50·30	1·00
Peareth and Pelton	6·50	50·40	1·50
Yorkshire Parrot	7·66	52·30	1·85
Wigan Cannel	7·55	57·00	1·93
Ramsay Parrot	12·00	62·00	3·40
Midlothian	13·00	60·00	3·56
Lesmahago	17·10	65·00	5·07
Scotch Parrot	15·00	80·00	5·46
Wemyss..............................	19·50	75·00	6·69
Kirkness	20·70	80·00	7·75
Boghead..............................	22·40	81·30	8·32

It will be noticed, that when the value of a gas is tested in this manner, it indicates a higher quality than we are accustomed to obtain by the photometer; but this he regards not as an error in his process, but as evidence that we do not use the best means to burn the gas to the best advantage; and consequently, that the illuminating power is, in the case of the richer cannels, a little below its true value.

TABLE OF THE ILLUMINATING POWER OF COAL GAS, ITS SPECIFIC GRAVITY, &c.

Coals.	Cubic feet of Gas per ton.	Illuminating Power.	Specific Gravity.	Condensed by Bromine.	Value in Grains Sperm.
		Candles.			
Boghead	15·000	37·75	·752	30·0	113·250
Lesmahago, No. 1 ...	13·500	27·10	·642	16·0	73·170
Wemyss	14·300	24·50	·580	14·0	70·070
Lesmahago, No. 2 ...	13·200	24·80	·618	17·0	65·472
Capeldrae..............	14·400	19·75	·577	16·5	56·880
Arniston	12·600	22·50	·626	17·0	56·600
Kirkness	12·800	21·20	·562	10·2	54·272
Knightswood	12·200	19·00	·550	9·5	50·160
Wigan (Ince Hall) ...	11·400	20·00	·528	11·5	45·600
Ramsay	10·300	21·40	·648	12·5	44·084
Pelton Cannel	11·500	18·50	·520	10·5	42·750
Leverson Cannel	11·600	18·00	·525	10·0	41·720
Washington Cannel...	10·500	18·00	·500	10·5	37·800
Brymbo Main	10·500	15·00	·549	6·8	31·500
Pelton Main	11·000	14·00	·430	4·5	30·800
Dean's Primrose	10·500	12·00	·430	5·0	28·350
Washington............	10·000	14·00	·430	5·0	28·000
Pelaw	11·000	12·75	·420	4·5	28·050
Brymbo Cannel	6·650	20·00	·504	11·5	27·160
Blenkinsopp	9·700	14·00	·450	6 0	27·160
Leverson	10·800	12·50	·425	4·0	27·000
West Hartley	10·500	12·50	·420	4·2	26·250
Hastings' Hartley ...	10·300	12·50	·421	4·3	25·750
New Pelton	10·500	12·00	·415	4·8	25·200
Garesfield..............	10·500	11·50	·398	3·8	24·150
Gosforth	10·000	12·00	·402	4·0	24·000

INTERNAL FITTINGS.

In order to avoid any inconvenience from lighting with gas, it is necessary that none should escape without being burnt. The fittings should therefore be sound, and carefully put together, and should be thoroughly examined, and ascertained to be perfectly tight, before the gas is turned into them; this can be done by condensing air into the pipes by means of a condensing syringe, and if the piston lowers after condensation, it is a sure indication that they are faulty. The leakages may be detected by passing a lighted taper carefully along the whole extent of the piping filled with condensed air, when the flame will be affected as it passes over the faulty places.

Testing Fittings.

Material for Fittings.

Iron is the best material for gas fittings, as it is less acted upon by gas than any other commercial metal; its decay results principally from the action of air and moisture, and takes place more on the outside than the inside.

Size of Pipes.

The pipes by which the gas is introduced should be of sufficient capacity to admit of a good supply when all the lights are burning together, and at that period of the evening when the greatest quantity of light is required—say, for instance, from sunset until 9 or 10 o'clock. Local situation should not be wholly disregarded; those consumers who happen to live on rising ground having an advantage over their less elevated neighbours. On this point it is better to be on the safe side by having the pipes too large rather than too small; the extra expense, in the first instance, being a mere trifle in the cost of materials, whilst it enables the consumer to alter or add to his lights, without disturbing the original arrangement of the fittings.

Arrangement of Pipes.

Accumulation of Water in Pipes.

Throughout their various ramifications the pipes should have a slight inclination towards the point where the main-cock is fixed, and thence to the street main. This is to allow the water which is occasionally deposited in them to drain off without interrupting the passage of the gas. In fittings which are not thus arranged, the water accumulates in some curvature of the

pipes and occasions an oscillation, or, as it is commonly called, a "jumping" of the lights. When this happens, the first thing to be ascertained is, whether the cause be general or partial, that is, if it exists in the street mains or in the consumer's fittings. If the lights in the immediate neighbourhood, and which are supplied from the main, burn steadily, it is a proof that the obstruction is in the fittings; but if they oscillate, it is in the main. If the obstruction is in the consumer's fittings, it is desirable to determine its situation, which may be done by turning off one light after another, beginning with that which oscillates most, until the rest burn steadily. If all the lights on the premises are affected alike, whether burning separately or in conjunction, then the cause must be sought for in the principal service pipe in connection with the main.

Syphons.

In some cases the pipes cannot be all inclined towards the street main or meter. Where this occurs, the lowest point must be provided with a syphon, generally consisting of a piece of tube with a stop-cock at the extremity. The condensed products must be drawn off at this stop-cock periodically.

Repairing and Cleaning Burners and Fittings.

The parts of fittings most subject to wear, or choking up, are the brass fittings, cocks, and burners, which should be occasionally taken out and cleaned, and, if necessary, repaired. The plugs of the cocks should be greased with tallow, so that they may work easily and be, at the same time, gas-tight. The burners should be cleaned frequently, taking care not to enlarge the apertures. For cleaning out argand, fishtail, and other perforated burners, a strong darning needle is the best instrument, and for slit burners, a piece of thin watch-spring or a slip of writing paper.

Stopping Leakages.

Where leakages exist they should be immediately searched for and stopped; for stopping small leakages temporarily, take a strip of calico, smeared with white lead, and bind it over the defective part. An escape of gas may exist for years without endangering either health or property, but it is equally unnecessary as unpleasant.

Shutting off Main-cocks.

When it can be done without inconvenience, the main-cock should be turned off at night; if it be required for bed-rooms or

nurseries this cannot be done unless the fittings are so arranged that the rooms requiring gas during the night are supplied by an independent set of pipes and fittings.

Freezing of Service Pipes.

If the service pipes are exposed to the external air, they will be liable to be obstructed by the freezing of the condensed vapour in frosty weather ; they should be therefore surrounded by some non-conducting material—as straw, woollen cloth, &c. ; when frozen, they must be thawed by means of hot water poured over them.

Water-slide Pendants.

Where water-slide pendants are used, care should be taken to keep the hydraulic tube full of water to prevent accident from escape of the gas. A good plan to prevent evaporation of the water is to add a teaspoonful of good salad oil after the tube has been filled with water.

Explosive Mixture of Gas, &c.

Gas is only explosive when it is mixed with air in various proportions ; the most explosive mixture is that of one volume of gas to eight of air, but all mixtures of air and gas, from one of gas to four of air, and one of gas to fourteen of air, are explosive ; and it is probable that explosions have taken place when only equal volumes of air and gas have been present.

Precautions to prevent Explosion.

When an escape of gas occurs, the room should be entered without a light, the door should be left open, and the top of the window lowered, so that the room is ventilated as much as possible ; before introducing a light, ascertain by smelling along the ceiling if the gas is gone ; if a light is in the room it should be extinguished, or lowered to the floor. Gas, on escaping, being lighter than air, ascends to the highest part of the room ; the law of diffusion of the gases begins to operate, and, in proportion to the escape, an explosive mixture is formed, though in the lower part of the room there will be scarcely any gas.

Cause of Gas going out suddenly.

If the gas goes out suddenly, and the meter used is a wet one, it is generally owing to want of water.

Regulating the Gas to the Burners.

In order to prevent the singing or hissing noise made by gas in passing through the burners, the cocks near the burners should be turned full on, and the gas supply regulated by means of a stop-cock placed at some distance from them.

Huddersfield and London.

Deposition of Carbon by Burners.

If the gas blackens the ceiling, the burner passes more gas than is properly consumed, and consequently, carbon is deposited in the form of soot.

Ventilation of Gas Burners.

The places or rooms lighted should be properly ventilated by any suitable means, as by apertures made in convenient places above the burners, by which the products of combustion may find their way into the open air.

Care of Fittings, &c.

The care of the fittings and of the lighting should be entrusted to some inmate or domestic, or where the consumer makes his own gas, the gas-maker or manager should make his inspections once or twice a week to see that all is in proper order.

Cooking by Gas.

Cooking by gas has many advantages over the common fire. Fire, for cooking, often requires considerable time in preparation. Gas, on the contrary, is lighted and applied instantly. Whilst fire, after the cooking is finished, is often allowed to go to waste, or makes the kitchen disagreeably hot, gas is extinguished as instantly as it is lighted, is much cleaner, and leaves no ashes, cinders, or dust. Where a small unvarying heat is required for pickling, stews, jellies, soups, preserves, &c., it is far preferable to coal; it only requires adjusting to the necessary heat, from which it will not deviate, and if required will simmer for hours without varying; it is particularly applicable to offices, workshops, and other places of business, where it is often inconvenient for persons, through pressure of business or the unfavourable state of the weather, to go home to their meals. It is useful to the early traveller to prepare his breakfast; all the necessary appendages of the breakfast table can be laid the night previous, and without disturbing the family or losing time in lighting a fire, he has only to light the gas; his water is boiling in a few minutes, and he enjoys his cup of tea or coffee without loss of time. A small heating burner is particularly useful in a bed-room in cases of sickness, where gruels or other warm drinks are constantly required; it is useful also where shaving or other warm water is requisite for the toilet.

In cooking meat by gas, it is roasted, not baked, as in the common kitchen oven; the difference being in baking, that the

meat is excluded from the air, whilst in the former it is exposed to a continual current which gives that peculiar flavour to roast meat which baked meat has not. The following will give an idea of the cost of cooking by gas, as ascertained by experiment :—

To cook	2 lbs. of mutton, with potatoes	13½	cubic feet of gas.
„	2 lbs. do., with pudding	12	„
„	1½ lbs. beefsteaks	5½	„
„	1 meat pie, containing 3 lbs. of beefsteaks	12¾	„
„	1 apple pie, same sized dish	7	„
„	2 pork pies, each 1 lb.	9½	„
„	2½ lbs. loaf	6	„
„	3½ lbs. potatoes, roasted	9	„

These articles were all cooked at different times with 75 feet of gas, amounting, at 5s. per 1,000 cubic feet, to 4½d. Two quarts of water were boiled in 14 minutes with 3½ cubic feet, and kept boiling for three hours by 11 cubic feet additional.

In a large London establishment in which 200 of the persons employed were boarded, the butcher's meat consumed in 1840 cost per head £12 11s. 10d.; in 1850, £9 11s. 7d.; whilst in 1860, the cost was reduced to £8 12s. per head. The explanation afforded is this : in 1840 the butcher's meat consisted of second-rate joints, containing a large quantity of bone. When roasted it was placed before a large fire, fixed on spits running through the joints, occasioning great waste, and producing indifferent results in the cooking, the outside being generally burnt, and the inside not sufficiently done. The inferior joints were abolished, and meat only of the best quality, free from bone, was purchased ; the spits were laid aside and the bottle-jack substituted. The open fire for roasting was still retained. This effected a saving of £3 0s. 2d. per head per annum. Another ten years passed, during which the open fire system was abandoned, and the plan of cooking by gas was introduced ; this caused a further saving of £1 0s. 4d. per head per annum, although the price of meat was higher by nearly 3d. per lb.—*Builder.*

Huddersfield and London.

RELATIVE COST, ADVANTAGES, &c., OF GAS.

The only correct method of estimating the relative cost of gas light, and of that obtained from tallow, wax, and oil, is by instituting the comparisons with equal quantities of light, each of the light-giving materials being used under the most favourable circumstances, and strictly in accordance with the plans pursued in actual practice. When gas is first introduced, it rarely happens that persons are satisfied with the same quantity of light as they had previously possessed. So long, however, as this extra supply is kept within moderate limits, it will cause no material difference in the results of the following calculations, since, with ordinary care, there need be no waste in the use of gas, whilst the most skilful management will not prevent waste with candles and lamps. Adopting as standards of comparison the following prices, namely :—

	s.	*d.*	
Tallow Candles (dips)	0	6	per lb.
„ „ (moulds)	0	8	„
Composition Candles	1	0	„
Wax Candles	2	4	„
Solar and Pale Seal Oil	4	0	per gallon
Sperm Oil	8	0	„

The relative cost of equal quantities of light from each material as compared with gas, at the respective prices quoted, will be as shown by the table.

COMPARATIVE COST OF LIGHT FROM CANDLES, LAMPS, AND GAS.*

	Quantities and Prices of Candles and Oil.			QUANTITIES AND PRICES OF GAS.				
				Cubic feet.	7*s.* per 1,000.		6*s.* per 1,000.	
		s.	*d.*		*s.*	*d.*	*s.*	*d.*
Tallow Candles (dips)†	1 lb.	0	6	21	0	1¾	0	1½
„ „ (moulds)	1 lb.	0	8	21	0	1¾	0	1½
Composition Candles‡	1 lb.	1	0	25	0	2⅛	0	1¾
Wax Candles	1 lb.	2	4	25	0	2⅛	0	1¾
Solar and Pale Seal Oil §	1 gallon	4	0	175	1	2¾	1	0⅝
Sperm Oil	1 gallon	8	0	217	1	6¼	1	3⅝

* The prices of candles and oil, although subject to occasional alterations,

On referring to the Table, it will be seen that where the price of gas is, for example, 6*s.* per thousand, a quantity sufficient to produce light equal to that to be obtained from a pound of tallow candles at 8*d.*, will cost only 1½*d.*, that is, less than one-fourth the cost of candles; compared with wax candles, the cost of gas light is only one-sixteenth; so, also, in comparison with the cheapest kinds of oil, the cost of gas light is little more than one-fourth, and compared with sperm oil, it is less than one-sixth.

COST OF GAS PER HOUR,

When burnt at the following Rates per 1,000 *Cubic Feet, in fractions of a Penny.*

Burner consuming in cubic feet per hour.	3s.	4s.	4s. 6d.	5s.	5s. 6d.	6s.	6s. 8d.	7s.	7s. 6d.	8s.	9s.	10s.	11s.	12s.	13s.	14s.	15s	16s.	17s.
2	·072	·096	·108	·120	·132	·144	·160	·168	·180	·192	·216	·240	·264	·288	·312	·336	·360	·384	·408
2½	·090	·120	·135	·150	·165	·180	·200	·210	·225	·240	·270	·300	·330	·360	·390	·420	·450	·480	·510
3	·108	·141	·162	·180	·198	·216	·240	·252	·270	·288	·324	·360	·396	·432	·468	·504	·540	·576	·612
3½	·126	·168	·189	·210	·231	·252	·280	·294	·315	·336	·378	·420	·462	·504	·546	·588	·630	·672	·714
4	·144	·192	·216	·240	·264	·288	·320	·336	·360	·384	·432	·480	·528	·576	·624	·672	·720	·768	·816
4½	·162	·216	·243	·270	·297	·324	·360	·378	·405	·432	·486	·540	·594	·648	·702	·756	·810	·864	·918
5	·180	·240	·270	·300	·330	·360	·400	·420	·450	·480	·540	·600	·660	·720	·780	·840	·900	·960	1·020

At a meeting of the members of the Manchester Corporation and their friends, to celebrate the laying of the foundation stone

are tolerably uniform at the same periods in all parts of the kingdom. It is not so, and never will be so, with respect to the prices of gas, which, to a great extent, are dependent upon local circumstances. This is not sufficient y understood, and yet it admits of an easy explanation. Coal being the staple material used in the manufacture of gas, the cost of which, taking the very lowest rates, varies in different localities from 4*s.* to 23*s.* per ton, it is evident that the prices of gas must thereby be affected. Nor is this the only cause of difference in prices; the cost of production, other conditions being equal, is greater in small establishments than in large ones. It would be as reasonable to expect that in small towns or districts, gas could be supplied at as cheap a rate as in those of ten or twenty times the extent, as that a single shawl or a piece of calico could be made by hand as cheaply as by machinery.

† Although dip candles cost less than moulds, they are liable to greater waste, and consequently cost, as respects light, as much or more than the latter.

‡ The average duration of composition and wax candles is less by two hours than that of common candles, but they yield more light, very nearly in the proportion of six to five.

§ If common oil be not used in a lamp expressly adapted for its perfect combustion, the waste of oil and deficiency of light will be so great as to render the cost of light actually obtained equal to double the amount at which it is here stated.

Huddersfield and London.

of a new retort-house in connection with the Manchester Gas Works, Mr. Rumney, the Chairman of the sub-committee, made the following important observations:—"A serious question for them was, whether it was likely there would ever be a cheaper artificial light; he thought there was no probability of such a thing at present. Experiments were made last winter by Dr. Frankland, an eminent chemist, now resident in London, and formerly of Owen's College, the result of which deserved to be widely known. He found that the illuminating power of 20 sperm candles for 10 hours would cost as follows in the several artificial lights named:—

	s.	d.
Spermaceti Candles	6	8
Paraffine ditto	3	10
Tallow ditto	2	8
Sperm Oil	1	10
Coal Gas	0	4½

Comparative effects of Gas, &c., on the Air.

"Another consideration was, that some persons complained of gas causing heat and impurity of the air, and it became a question as to whether it created more heat and impurity than other artificial lights." The same gentleman conducted experiments to find that out, with these results:—Taking the illuminating power of 20 sperm candles as the standard, it was found that in a room of a certain size, and in a given time, tallow candles produced 10 cubic feet of carbonic acid gas, and an amount of heat represented by 100.

Spermaceti Candles	produced	8·3 cubic feet of carbonic acid gas, and heat	82
Paraffine	"	6·7 " " " "	66
Coal Gas	"	5 " " " "	47

This disposed of the idea that gas caused more heat, and made the atmosphere more impure, than other artificial lights.—*Manchester Guardian, October 13th*, 1863.

"There are thousands who firmly believe that coal gas, in burning, gives off some highly deleterious agents, from which wax, tallow, oil, and even coals themselves, are entirely free; and this belief is supposed to possess corroborative testimony in the shape of facts displayed in the creation of disease, or in the

misconceived opinions of medical men. Now the real truth of the matter is, that whether gas be burnt under the name of gas or not, can make no difference to the advocates of this strange prejudice, for under all the circumstances used in the ordinary burning of wax, tallow, oil, &c., it is gas, and nothing but gas, that is burnt; the only difference being that coal gas is always purified before it is consumed, whereas the extemporaneous gas of a candle or lamp is consumed without being purified at all; and hence, light for light, it must and does vitiate the air of an apartment vastly more than coal gas. If, therefore, it be true that gas is insalubrious, then wax and oil must be decidedly more so, from the simple fact that all the impurities they evolve pass into the atmosphere of the localities lighted, whereas the great bulk at least of those from coal gas remain at the gas works. The actual question for the public to consider is, not whether the burning of gas be injurious to health, for in one shape or other gas must be burnt to procure light, but the point is, whether it is better to consume for this purpose gas of pure or impure quality." *

Comparative Safety of Gas.

"In addition to its greater economy, gas light may also be pronounced safer than any other ordinary light. It produces no sparks; it cannot be carelessly placed in contact with bed curtains, or substances easily ignited; and it requires scarcely any attention. It may be turned down in an instant to the most minute speck of flame, ready to be restored when necessary by the simple turning of the stop-cock; and even when it escapes by the carelessness of an attendant or a defect in the fittings, it at once indicates the action to the whole household by the disagreeable smell which it occasions. From the large quantity that must be mixed with the air before it becomes explosive, it is scarcely possible that this accident should occur in any ordinary apartment, even if the gas were allowed to escape on purpose; and as its smell so well indicates its presence in cellars, or other confined situations, where it may have escaped in quantity from

* "The Nature and Chemical Properties of Coal Gas." By Lewis Thompson, M.R.C.S.

the accidental breakage or leakage of a pipe, it is only by the grossest carelessness or ignorance that a light will be approached to it before it has been allowed to escape by the free admission of air. There is no such thing as the bursting of a pipe, or the blowing up of a gas-holder; a gas pipe may be broken, or any other pipe, by accident, and if a leaky gas-holder is covered over by a building, an explosion may then take place; but these are accidents which can very rarely occur, and they do not concern in any way the ordinary consumer of gas."—*Chambers' Information for the People.*

Effects of Gas Light on the Eyesight.

"It is sometimes said that gas light is injurious to the eyes. During twenty years of careful observation and inquiry, no instance of the kind has ever come to my knowledge. A powerful light, imprudently used, or improperly directed, might be expected to be hurtful; but, in that case, light from oil, tallow, wax, or turpentine, would be equally objectionable as that from gas. To say that a good light, in the sense in which the term is here employed, is injurious, and that an indifferent or bad one is not so, is about as reasonable as to affirm that the light of the moon is more useful than that of the sun, or that it is easier and more congenial to the feelings to read, or write, or work, by fire light, than from that by candles; the eyes are more distressed, and sight more impaired, by a few days of overstraining in the dimness of candle light, than by years of closer application in the light from a purely regulated gas burner. A good gas light, producing as near as possible the same effects as diffused sun light, placed at a proper distance from and above the eyes, is not injurious, but on the contrary, exceedingly agreeable and eminently preservative. The direction in which artificial light falls upon the eyes has not received sufficient attention. Table lamps and candles are in most instances too low, that is, the light is too near the plane of the axis of the eyes to be comfortable, or to produce the best illuminating effects. The natural, and therefore the most appropriate position for the light, is at a

* Many insurance offices now charge a lower rate for buildings when lighted with gas, than when lighted with candles, oil, or naphtha.

convenient distance above the eyes, the angular direction being of course dependent on the height and dimensions of the room."—J. N. O. Rutter, F.R.A.S.

Lighting Picture Galleries by Gas.

Extracts from the Report of the Commissioners appointed to consider the subject of lighting picture galleries by gas :—Professors Faraday, Hoffman, and Tyndall, Captain Fowkes, R.E., and Mr. R. Redgrave, R.A.

"There is nothing innate in coal gas which renders its application to the illumination of picture galleries objectionable. Its light, though not so white as that of the sun, is equally harmless; its radiant heat may be rendered innocuous by placing a sufficient distance between the gas jets and the pictures, while the heat of combustion may be rendered eminently serviceable in promoting ventilation."

"Coal gas may be free from sulphuretted hydrogen, and in London is so at the present time; it then has little or no direct action on pictures. But it has not, as yet, been cleansed from sulphide of carbon, which in combustion yields sulphurous acid gas, capable of producing 22½ grains of sulphuric acid per 100 cubic feet of London coal gas. It is not safe to permit this product of the combustion to come in contact with pictures painted either in oil or water colours; and the Commission are emphatically of opinion, that in every system of permanent gas-lighting for picture or sculpture galleries, provision should be made for the effectual exclusion or withdrawal of the products of combustion from the chambers containing the works of art."

"The Commission have examined the Sheepshanks Gallery, as an experimental attempt to light pictures with gas, and are of opinion that the process there carried out fulfils the condition of effectually illuminating the pictures, and at the same time removing the products of combustion. According to the indications of the thermometer required and obtained, it does this in harmony with, and in aid of the ventilation, and does not make a difference of more than one degree Fahrenheit, at the parts where the pictures

are placed, between the temperatures before and after the gas is lighted."

"Certain colour tests, consisting of surfaces covered with white lead, or with vegetable and mineral colours (especially the more fugitive ones), and in which also boiled linseed oil, magylph, and copal varnish were employed as vehicles, had been prepared, and were, when dry, covered one-fourth with mastic varnish, one-fourth with glass, one-fourth with both mastic varnish and glass, and one-fourth left uncovered. Sixteen of these have been placed for nearly two years in different places, in some of which gas has been used, and in others not. They give no indications respecting the action of coal gas (excepting injury from heat in one placed purposely, and very near to, and above the gas burners), but seven of them show signs of chemical change in the whites, due to either a town atmosphere, or want of ventilation; the others present no observable change."

EFFECTS OF THE BOMBARDMENT OF PARIS ON THE GAS WORKS.

As regards the damage done to the several works in the course of the bombardment, we have some valuable details, which we must put on record here for the information of those who persist in believing in the danger of stores of gas. The Governor of Paris entertained a notion of this sort, and thought the works at La Villette were dangerous to the fortifications in the vicinity. The company assured him that there was not the smallest risk. "If" they said, "a projectile made a hole in a gas-holder, and set fire to the gas, the gas would simply burn out as a jet of flame. The constant pressure of the gasholder would effectually prevent any access of air, and therefore there could be no such thing as an explosion." This happened exactly at Ivry. A shell pierced the gasholder, and lighted the gas. There was a huge jet of fire for eight minutes, the holder slowly sank, and all was over. A more curious incident occurred at La Villette.

Here a shell penetrated a gas-holder *and burst in the interior without igniting the gas.* Nine fragments made their way out in different directions; but the servants of the company, with great coolness and dexterity, stopped the holes with plugs prepared for such an emergency, and so saved the greater part of the gas. At La Villette, also, a shell perforated the bell of a governor, and set fire to the gas; but there was no explosion. The fire was promptly extinguished, but the furniture in the office was destroyed by the explosion of the shell. At Vaugirard, where a great number of shells fell, only one penetrated a gas-holder, and here again there was neither ignition nor explosion. These incidents, it is to be hoped, will set men's minds at rest for ever as to the supposed dangers of gas-holders.—*Journal of Gas-lighting, August 1st,* 1871.

SUNDRY NOTES ON GAS.

A difference of one inch in the pressure of the gas will make a difference in the volume of 1,000 cubic feet of gas of 2·40 cubic feet; or in 1,000,000 cubic feet, of 2,400 cubic feet; being about one-quarter per cent. increase; 1,000,000 cubic feet of gas, therefore, at 3 inches pressure, when distributed at 1 inch pressure, should measure 1,004,800, or, in 1,000 millions, an increase of 4,800,000 cubic feet.

A difference of temperature between the station meter and the mains will also make a difference in the quantity of gas. For instance:—If the gas passing through the station meter be at 50° Fahr., and in the mains at 32° Fahr., the station meter will register 1,043 millions of cubic feet, whilst 1,000 millions only will be registered or distributed in the mains at the reduced temperature.

It is found that the illuminating power of gas decreases in proportion to the length of main through which it travels. Mr. F. J. Evans states that to obtain a light equal to 14 candles at a distance of two miles from the works, 16-candle gas must be made; the larger the proportion of cannel, the greater the loss.

Huddersfield and London.

Dr. Frankland has found that a gas flame or candle gave less light according to the rarefaction of the air in which it was burning; and his results show the loss of light to be about 5·1 per cent. for every inch of diminished mercurial pressure up to a rarefaction of 14 inches. If, for example, the light of a flame be equal to 100 at 30 inches of the barometer, it is but 94·9 at 29·1 inches, 89·8 at 28 inches, and so on to 14 inches, when it is only 18·4 per cent. of the original light. This deficiency would increase with the expansion in the volume of the gas from increase of temperature and rarefaction. In London, therefore, the difference in the value of the light at 31 inches and 28 inches is fully 25 per cent.

In warm weather the volatility of naphtha is increased, and therefore a larger amount of hydro-carbon vapour is given to the gas:—

	Temperature.	Naphtha absorbed per foot of Gas.	Percentage increase of Illuminating Power.
Spring	41° Fahr.	5·25 grains	23·6
Summer	72° „	12·09 „	54·4
Autumn	62° „	10·77 „	48·5
Winter	37° „	4·94 „	22·2

On lighting the gas in factories, the warmth diffused renders the *oil* more limpid, increases its lubricating value, and thereby enables the machinery to be driven with less power.

When gas is used as fuel for raising steam in boilers, 20 cubic feet of gas are found to be equal to 1lb. of coal.

India-rubber is pervious to gases in the following order:— Ammoniacal gas, 1 minute; sulphuretted hydrogen, 2½ minutes; cyanogen, 3½ minutes; carbonic acid, 5½ minutes; protoxide of nitrogen, 6½ minutes; arseniuretted hydrogen, 27½ minutes; olefiant gas, 28 minutes; hydrogen, 37½ minutes; oxygen, 1 minute 53 seconds; carbonic oxide, 2 minutes 40 seconds.

When a consumer's meter is new, it will be propelled with one-tenth of an inch pressure.

Instances have been known where composition and lead pipes have been gnawed into holes by rats.

W. C. Holmes & Co.,

A 20-light meter is required for a 1-horse power Lenoir's engine.

Carburetted hydrogen will combine chemically with copper, nitrate of silver, and other saline compounds, and form a substance of a highly explosive nature; accidents have repeatedly happened, which are ascribed to the use of copper pipes for the transmission of gas.

The vapour of tar ignites at 200°.

The quantity of air blown into the bottom of a blast furnace may be estimated by weight at 18 tons for each ton of iron made. The total weight of the solids and gases amounts to 19 tons. In the furnace 3 tons of this escape from the bottom in a liquid form, while 16 tons of gaseous matter escape from the top.

Lights are extinguished when the proportion of nitrogen in the air amounts to from 5 to 8 per cent., and at the latter point suffocation ensues. An excess of 1-500th in the surface atmosphere begins to occasion an injurious effect.

The presence of 1-5000th part of sulphuretted hydrogen in the air is said to act injuriously on the constitution. Air containing 1-250th part has been known to kill a horse, and 1-1500th part a bird.

In summer the production of gas per ton of coal is usually less than in winter. This is owing, in the first place, to the fact that with cold ovens on either side, the heats cannot be kept up so well; and secondly, on account of the diminished production of gas, which, having to pass over the same area of cooling surface as in winter, has its temperature reduced, and the volume of gas due to such reduction of temperature being registered by the station meter, the production is apparently less. The condensers should therefore be arranged so that their cooling effects can be regulated to meet the varying requirements of the season (see page 21).

Coal, when slaked with water, weighs from 20 to 25 per cent. more than when unslaked.

A chaldron of coke weighs from 12½ to 15 cwt.

Huddersfield and London.

Care should be taken to keep the seal-cups of telescopic gas-holders perfectly clear, and free from ice or other solid substances. The crowns of gas-holders, whether single or telescopic, should also be cleared from snow, especially when drifted to one side.

A fall of about 12 inches in 200 yards should be given to main pipes on level ground, and a syphon-box placed at the lowest point.

Wrought-iron service pipes should be renewed about every twelve years.

In calculating the amount of gas required for illuminations, each jet of an illumination device should be taken as consuming one cubic foot of gas per hour.

Two-inch cast-iron main pipes are too small to be drilled and tapped for services with safety; a T pipe should be placed in the main instead.

Service pipes for street lamps should never be less than ¾ths of an inch bore.

Foul glass gauge-tubes may be cleaned by washing with a dilute solution of sulphuric acid, and rinsing afterwards with distilled water.

Recipe for coating Gas-holders.

One gallon of tar; ½ lb. of asphalte; ½ lb. of tallow; 1 pint of coal naphtha.

Mix the tar and asphalte together, and heat them up to the boiling point, then add the tallow and naphtha, and lay the mixture on before it cools.

TO FIND THE PRESSURE ON GAS DUE TO THE WEIGHT OF GAS-HOLDER.

Multiply the superficial area of the gas-holder by the weight of one square foot of water one inch thick, and use this quotient as a divisor into the total weight of gas-holder and guide rollers, &c., attached thereto, in pounds; the result will be the pressure in inches head of water.

Example:—What will be the pressure on the gas in a gas-holder 50 feet in diameter and 16 feet deep, the weight of

which is, inclusive of top and bottom guide rollers, 12 tons, or 26,880 lbs.?

Area 1,963·5 lbs.
Weight of 1 sq. ft. of water, 1 in. thick } 5·2) 10,210·20) 26,880 ($2\frac{6}{10}$ inches. Answer.
20,420
6,460

In order to ascertain the amount of counterbalance weights required to regulate the gas-holder to a certain given pressure, it is only necessary to multiply the quotient 10,210·20 by the desired pressure, and subtract the quotient from the weight of the gas-holder in pounds. Thus, if the pressure desired be 2 inches in this case, the weight of the counterbalance will be 6,460 lbs.; or if a pressure of 1½ inches only be required, then

10,210·20
1·5
15,315·3

which, deducted from 26,880, leaves 11,564·7 lbs. as the counterbalance required.

To find the weight of a gas-holder, the working pressure being given, multiply the superficial area of the gas-holder by 5·2 and by the pressure in inches and tenths.

RAPIDITY AND FORCE OF WINDS.

(This Table is useful to show the amount of force exerted on the surface of a Gas-holder by a gale of Wind.)

Velocity in miles per hour.	Force on one square foot in pounds Avoirdupois.	Appellation.
1	·005	Hardly perceptible.
4	·079	Gentle Breeze.
5	·123	
10	·492	Pleasant, brisk Gale.
15	1·107	
20	1·968	Very brisk.
25	3·075	
30	4·429	High Wind.
35	6·027	
40	7·873	Very high.
50	12·300	Storm.
60	17·715	Great Storm.
80	31·490	Hurricane.
100	49·200	Violent Hurricane.

Huddersfield and London.

WEIGHTS AND MEASURES.

Troy Weight.

4 grains = 1 carat

24	6	1 dwt.				
480	120	20	1 ounce.			
5,760	1,440	240	12	1 lb.		
86,400	21,600	3,600	180	25	1 qr.	
576,000	144,000	24,000	1,200	100	4	1 cwt.

Gold, silver, jewels, liquids, &c., are weighed by this weight.

Avoirdupois Weight.

16 drachms = 1 ounce.

256	16	1 lb.			
7,168	448	28	1 qr.		
28,672	1,792	112	4	1 cwt.	
573,440	3,5840	2,240	80	20	1 ton.

7,000 Troy grains = 1 lb. Avoirdupois.

Apothecaries' Weight.

20 grains = 1 scruple.

60	3	1 drachm.		
480	24	8	1 ounce.	
5,760	288	96	12	1 lb.

Apothecaries' Fluid Measure.

60 minims	make	1 fluid drachm.
8 fluid drachms	„	1 fluid ounce.
16 fluid ounces	„	1 pint.
8 pints	„	1 gallon.

The minim of water is as nearly as possible the natural drop, but not of other substances, the drops of which vary with their several tenacities.

Wool Weight.

7 lbs. 1 clove.

14	2	1 stone.				
28	4	2	1 tod.			
182	26	13	6·5	1 wey.		
364	52	26	13	2	1 sack.	
4,368	624	312	156	24	12	1 last.

240 lbs. = 1 pack. A German bale = 350 lbs.

W. C. Holmes & Co.,

Wine Measure.

2 pints	1 quart.						
8	4	1 gallon.					
336	168	42	1 tierce.				
504	252	63	1·5	1 hogshead.			
672	336	84	2	1⅓	1 puncheon.		
1,008	504	126	3	2	1½	1 pipe.	
2,016	1,008	252	6	4	3	2	1 tun.

Ale Measure.

2 pints	1 quart.								
8	4	1 gall.							
72	36	9	1 firkin.						
144	72	18	2	1 kilderkin.					
288	144	36	4	2	1 barrel.				
432	216	54	6	3	1·5	1 hhd.			
576	288	72	8	4	2	1·5	1 puncheon.		
864	432	108	12	6	3	2	1·5	1 butt.	
1,728	864	216	24	12	6	4	3	2	1 tun.

Dry Measure.

8 pints	1 gall.						
16	2	1 peck.					
64	8	4	1 bushel.				
256	32	16	4	1 coomb.			
512	64	32	8	2	1 quarter.		
2,560	320	160	40	10	5	1 wey, load or chldrn.	
5,120	640	320	80	20	10	2	1 last.

The standard bushel contains 2,218½ cubic inches, and measures 19½ inches diameter, and 8¼ inches deep.

Coal Measure.

4 pecks	1 bushel.			
12	3	1 sack.		
144	36	12	1 chaldron.	
3,024	756	252	21	1 score.

Long Measure.

3 brlycns.	1 inch.						
36	12	1 foot.					
108	36	3	1 yard.				
216	72	6	2	1 fathom.			
594	192	16·5	5·5	2·75	1 rod,pole,or prch.		
23,760	7,920	660	220	110	40	1 furlong.	
190,080	63,360	5,280	1,760	880	320	8	1 mile.

Solid Measure.

1,728 inches	1 foot.		
46,656	27	1 yard.	
373,248	216	8	1 fathom.

Square Measure.

144 inches	1 foot.				
1,296	9	1 yard.			
39,204	272¼	30¼	1 pole.		
1,568,160	10,890	1,210	40	1 rood.	
6,272,640	43,560	4,840	160	4	1 acre.

Cloth Measure.

2¼ inches	1 nail.	3 quarters	1 Flemish ell.
4 nails	1 quarter.	5 „	1 English ell.
4 quarters	1 yard.	6 „	1 French ell.

4 rods, or 100 links, or 22 yards = 1 chain of land.

Time.

60 seconds	1 minute.
60 minutes	1 hour.
24 hours	1 day.
7 days	1 week.
4 weeks or 28 days	1 lunar month.
365 days 6 hours	1 Julian year.
365 days, 5 hours, 48 min. and 57 secs.	1 solar year.
100 years	1 century.

The leap-year is found by dividing by 4; if even, it is leap-year; if odd, so many after leap-year.

Geometrical Time.

60 seconds	1 minute.
60 minutes	1 degree.
90 degrees	1 quadrant.
4 quadrants	1 circle.

The standard for gold coin in Great Britain is 11 parts fine gold and 1 of alloy, 1 pound troy of which is coined into 46 sovereigns and $\frac{89}{120}$ of another. The standard for silver coin is a mixture of 37 parts of fine silver and 3 of alloy, 1 pound troy of which is coined into 66 shillings.

W. C. Holmes & Co.,

MISCELLANEOUS WEIGHTS AND MEASURES.

Article.	Receptacle.	Weight or Measure.	Article.	Receptacle.	Weight or Measure.
Ash	1 ton	45 c. ft.	League, French ...	...	2¾ miles
Ballast, pig ...	...	56 lbs.	Ditto, Spanish ...	...	3⅜ miles
Barley	Bushel	50 lbs.	Do., Ancient Greek	...	1,624 yds.
Bricks	Load	500	Lime	Load	32 bus.
Beech	1 ton	51 c. ft.	Mahogany ...	1 ton	34 c. ft.
Bullion, bar ...	...	15 to 30 lbs.	Mile	...	1,760 yds.
Brickwork ...	1 rod	272 sq. ft.	Ditto, German ...	...	4 miles
		14 in. thick	Ditto, Dutch ...	...	3⅛ miles
Coals	Keel of 8		Ditto, Italian ...	...	1,467 yds.
	Newcastle		Ditto, Scotch ...	...	1,984 yds.
	chaldrons	21 tons	Ditto, Irish ...	...	2,200 yds.
"	Newcastle		Ditto, Polish ...	...	3½ mls.
	chaldron	52½ cwt.	Ditto, Swedish ...	...	5 to 6 mls.
Cable's length ...	60 yards	...	Ditto, Danish ...	...	Ditto
Chalk	13 c. ft.	1 ton	Ditto, Hungarian	...	Ditto
Clay	17 c. ft.	1 ton	Ditto, Arabian ...	...	2,148 yds.
Earth	1 ton	18 c. ft.	Ditto, Nautical ...	...	6,075¾ ft.
Elm	1 ton	60 c. ft.	Ditto, Persian, or		
Fir	1 ton	65 c. ft.	Parasang ...	...	6,086 yds.
Gunpowder ...	Barrel	100 lbs.	Ditto	1 degree	$69\frac{1}{15}$ mls.
Ditto	Last	24 brls.	Ditto	1 ditto,	
Glass	Seam	124 lbs.		Geogra	60 miles
Ditto	Stone	5 lbs.	Nails	Hundred	120
Gravel	1 ton	21¾ ft.	Ditto	1,000	1,200
Gross	...	12 doz.	Nightsoil... ...	Ton	18 c. ft.
Gross, great ...	...	12 gross	Oak	1 ton	39 c. ft.
Hand	...	4 inches	Oil, vegetable ...	Tun	286 Imp.
Hemp	Bale	Nearly			gallons
		20 cwt.	Ditto, train ...	Gallon	10½ lbs.
Ditto	Stone	32 lbs.	Ditto, animal ...	Tun	252 galls.
Hay or Straw ...	Truss	36 lbs.	Ditto, common ...	Gallon	9·32 lbs.
Ditto, old ...	Ditto	56 lbs.	Ditto, olive ...	Chest of	
Ditto, new ...	Ditto	60 lbs.		60 flasks	125 galls.
Ditto	Load	36 trusses	Ditto, ditto ...	Jar	25 galls.
Lead, Black ...	Cask	About	Oats	Bushel	40 lbs.
		11½ cwt.	Parchment ...	Roll	60 skins
Ditto, London ...	Fother	19½ cwt.	Pitch or tar ...	Last	12 barrls.
Ditto, Stockton ...	Ditto	22 cwt.	Ditto, Burgundy...	Stand	1½ cwt.
Ditto, Newcastle...	Ditto	21 cwt.	Palm	...	3 inches
Land	Sq. mile	640 acres	Pace	...	5 feet
Ditto	Yard	30 acres	Quicksilver ...	Bottle	Abt. 84 lbs.
Ditto	Hide	100 acres	Resin	Barrel	2 cwt.
Ditto	Barony	40 hides	Steel	Fagot	120 lbs.
Ditto, Woodland...	Pole	18 ft.	Sand	1 ton	24 c. ft.
Ditto, Plantation	Ditto	21 ft.	Ditto	Load	36 bshls.
Ditto, Cheshire ...	Ditto	24 ft.	Salt	1 last	18 barrls.
Ditto	1,089	1,369	Ditto	Hundred	7 lasts
	Scotch acs.	Eng. acs.	Span	9 inches	...
League	...	3 miles	Spirits, proof ...	Gallon	9·3 lbs.

Huddersfield and London.

MISCELLANEOUS WEIGHTS AND MEASURES—*continued.*

Article.	Receptacle.	Weight or Measure.	Article.	Receptacle.	Weight or Measure.
Stone	14 lbs.	...	White Lead ...	Cube ft.	197·5 lbs.
Tallow	Cask	Abt. 9 cwt.	Water, distilled ...	Ditto	62·5 lbs.
Ditto	Cube ft.	59 lbs.	Ditto, sea... ...	Ditto	64·25 lbs.
Tar	Barrel	26½ galls.	Verst, Russian ...	...	1,100 yds.
Ditto	Cube ft.	63·43 lbs.	*Stone:*		
Tiles	Load	1,000	Marble	1 ton	13 c. ft.
Turpentine ...	Barrel	2 to 2½ cwt.	Granite	Ditto	13½ c. ft.
Ditto, Oil of ...	Cube ft.	54·37 lbs.	Purbeck Stone ...	Ditto	14 c. ft.
Timber, unhewn...	Load	40 c. ft.	Yorkshire Stone ...	Ditto	14½ c. ft.
Ditto, squared ...	Ditto	50 c. ft.	Derbyshire Grit...	Ditto	16 c. ft.
Ditto, 1-in. boards	Ditto	600 sq. ft.	Portland Stone ...	Ditto	17 c. ft.
Ditto, 2-in. planks	Ditto	300 sq. ft.	Bath Stone ...	Ditto	18 c. ft.
Ditto, Deals ...	100	120 sq. ft.	York Paving, 3 in. thick	Ditto	58 ft. supr.
Ditto, Flooring ...	Square	100 sq. ft.	Ditto, 2½ ditto ...	Ditto	70 ft. supr.
Ditto	Stack	108 c. ft.			
Wood, Firewood	Cord	4 ft. × 4 ft. × 8 ft. dp.			

In buying and selling medicines, Avoirdupois weight is used.

10 lbs. Avoirdupois of distilled water at 62° Fahrenheit is equal to one gallon.

A cubic foot is equal to 2,200 cylindrical inches, 3,300 spherical inches, 6,600 conical inches, or 1,728 square inches.

A strike is properly two bushels, but in some districts these terms are reversed—the one for the other.

A ton of shipping is 42 cubic feet, holding 24 cwt. of sea water.

A cycle, in chronology, is 19 years, or 235 lunations.

Snow, when melted, produces about one-eighth its bulk of water.

WEIGHT OF CAST IRON GAS PIPES PER YARD.

2	3	4	5	6	7	8	9	10	12 in.
21	33	51	70	89	107	126	149	177	208 lbs.

W. C. Holmes & Co.,

WEIGHT OF A SUPERFICIAL FOOT OF VARIOUS METALS.

Thickness in inches.	Wrought Iron.	Cast Iron.	Steel.	Copper.	Brass.	Lead.	Zinc.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/16	2·526	2·344	2·552	2·891	2·734	3·708	2·344
1/8	5·052	4·687	5·104	5·781	5·469	7·417	4·687
3/16	7·578	7·031	7·656	8·672	8·203	11·125	7·031
1/4	10·104	9·375	10·208	11·563	10·938	14·833	9·375
5/16	12·630	11·719	12·760	14·453	13·672	18·542	11·719
3/8	15·156	14·062	15·312	17·344	16·406	22·250	14·062
7/16	17·682	16·406	17·865	20·234	19·141	25·958	16·406
1/2	20·208	18·750	20·417	23·125	21·875	29·667	18·750
9/16	22·734	21·094	22·969	26·016	24·609	33·375	21·094
5/8	25·260	23·437	25·521	28·906	27·344	37·083	23·437
11/16	27·786	25·718	28·073	31·797	30·078	40·792	25·781
3/4	30·312	28·125	30·625	34·688	32·813	44·500	28·125
13/16	32·839	30·469	33·177	37·578	35·547	48·208	30·469
7/8	35·365	32·812	35·729	40·469	38·281	51·917	32·812
15/16	37·891	35·156	38·281	43·359	41·016	55·625	35·156
1	40·417	37·500	40·833	46·250	43·750	59·333	37·500

WEIGHT OF A SUPERFICIAL FOOT OF IRON, COPPER, AND BRASS.

Birmingham Wire Gauge thickness.	Iron.	Copper.	Brass.	Birmingham Wire Gauge thickness.	Iron.	Copper.	Brass.
	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.
1	12·50	14·50	13·75	16	2·50	2·90	2·75
2	12·00	13·90	13·20	17	2·18	2·52	2·40
3	11·00	12·75	12·10	18	1·86	2·15	2·04
4	10·00	11·60	11·00	19	1·70	1·97	1·87
5	8·74	10·10	9·61	20	1·54	1·78	1·69
6	8·12	9·40	8·93	21	1·40	1·62	1·54
7	7·50	8·70	8·25	22	1·25	1·45	1·37
8	6·86	7·90	7·54	23	1·12	1·30	1·23
9	6·24	7·20	6·86	24	1·00	1·16	1·10
10	5·62	6·50	6·18	25	·90	1·04	·99
11	5·00	5·80	5·50	26	·80	·92	·88
12	4·38	5·08	4·81	27	·72	·83	·79
13	3·75	4·34	4·12	28	·64	·74	·70
14	3·12	3·60	3·43	29	·56	·64	·61
15	2·82	3·27	3·10	30	·50	·58	·55

Huddersfield and London.

WEIGHT OF ONE FOOT IN LENGTH OF VARIOUS METALS, ROUND.

Diameter in inches.	Wrought Iron.	Cast Iron.	Steel.	Copper.	Brass.	Lead.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
$\frac{1}{4}$	·163	·152	·167	·188	·17	...
$\frac{3}{8}$	·368	·304	·376	·42	·39	...
$\frac{1}{2}$	·654	·61	·669	·75	·79	...
$\frac{5}{8}$	1·02	·95	1·04	1·17	1·1	...
$\frac{3}{4}$	1·47	1·38	1·5	1·69	1·59	...
$\frac{7}{8}$	2·00	1·87	2·05	2·31	2·16	...
1	2·61	2·45	2·67	3·02	2·83	3·87
$1\frac{1}{8}$	3·31	3·10	3·38	3·86	3·58	4·9
$1\frac{1}{4}$	4·09	3·83	4·18	4·71	4·42	6·06
$1\frac{3}{8}$	4·95	4·64	5·06	5·71	5·35	7·33
$1\frac{1}{2}$	5·89	5·52	6·02	6·8	6·36	8·72
$1\frac{5}{8}$	6·91	6·48	7·07	7·94	7·47	10·24
$1\frac{3}{4}$	8·01	7·51	8·20	9·21	8·66	11·87
$1\frac{7}{8}$	9·20	8·62	9·41	10·61	9·95	13·63
2	10·47	9·81	10·71	12·08	11·32	15·51
$2\frac{1}{8}$	11·82	11·08	12·08	13·64	12·78	17·51
$2\frac{1}{4}$	13·25	12·42	13·52	15·29	14·32	19·63
$2\frac{3}{8}$	14·76	13·84	15·09	17·03	15·96	21·8
$2\frac{1}{2}$	16·36	15·33	16·72	18·87	17·68	24·24
$2\frac{5}{8}$	18·03	16·91	18·45	20·8	19·5	26·72
$2\frac{3}{4}$	19·79	18·56	20·24	22·8	21·4	29·33
$2\frac{7}{8}$	21·63	20·28	22·13	24·9	23·4	32·05
3	23·56	22·08	24·09	27·18	25·4	34·9
$3\frac{1}{4}$	27·65	25·92	28·28	31·76	29·8	40·9
$3\frac{1}{2}$	32·07	30·06	32·8	36·8	34·6	47·4
$3\frac{3}{4}$	36·81	34·51	37·6	42·4	39·8	54·5
4	41·88	39·27	42·8	48·3	45·2	62
$4\frac{1}{4}$	47·28	44·27	48·32	54·5	51·1	70
$4\frac{1}{2}$	53·01	49·7	54·0	61·1	57·2	78·5
$4\frac{3}{4}$	59·06	55·37	60·36	68·1	63·8	87·2
5	66·00	61·35	66·88	75·48	70·7	96·9
$5\frac{1}{4}$	72·76	67·64	73·80	83·2	78	106·8
$5\frac{1}{2}$	79·85	74·24	80·9	91·2	85·6	117·3
$5\frac{3}{4}$	87·28	81·14	88·52	99·6	93·6	128
6	95·03	88·35	96·0	108·7	101·8	139·6
$6\frac{1}{2}$	111·53	103·69	113·1	127	119·2	163·6
7	129·35	120·26	131·2	147·2	138·4	189·6
$7\frac{1}{2}$	148·59	138·05	150·4	169·6	159·2	218
8	168·95	157·08	171·2	193·2	180·8	248
$8\frac{1}{2}$	190·73	177·1	193·28	218·0	204·4	280
9	213·83	198·79	216	244	228 8	314
$9\frac{1}{2}$	238·25	221·5	241·44	272	255·2	348·8
10	264·00	245·43	267·52	302	282·8	387·6
$10\frac{1}{2}$	291·05	270·59	295·20	332·8	312	427·2
11	319·43	296·97	323·6	364·8	342	469·2
$11\frac{1}{2}$	349·10	324·59	354·08	398·4	374	512
12	380·13	353·43	384	434·8	407	558·4

FRENCH WEIGHTS AND MEASURES,

DECIMAL SYSTEM.

Long Measure.

French.	*English.*
Millimètre	0·0393 inches
Centimètre	0·3937 „
Décimètre	3·9371 „
Mètre	39·371 „
„	3·2809 feet
„	1·0936 yards
Décamètre	32·809 feet
Hectomètre	328·09 „
Kilomètre	1093·639 yards
Myriamètre	6·2138 miles

Square Measure.

French.	*English.*
Milliare	155 sq. inches
Centiare, or square mètre	10·764 sq. ft.
Déciare	11·960 sq. yds.
Are, or square décamètre	119·60 „
Décare	1196·046 „
Hectare	2·4712 acres

Solid Measure.

French.	*English.*
Millistère	61·028 cubic inches
Centistère	610·28 „ „
Décistère	3·5317 „ feet
Stère, or cubic mètre	35·317 „ „
Décastère	13·080 „ yards
Hectostère	130·80 „ „

Dry and Fluid Measure.

French.	*English.*
Millilitre	0·0610 cubic inches
Centilitre	0·6103 „ „
Décilitre	6·1028 „ „
Litre, or cubic décimètre	61·028 „ „
„ „ „	1·761 imperial pint

Huddersfield and London.

Dry and Fluid Measure—*continued.*

French.					*English.*
Décalitre	-	-	-	610·28	cubic inches
"	-	-	-	2·2	imperial galls.
Hectolitre	-	-	-	3·5317	cubic feet
"	-	-	-	2·75	imp. bushels
Kilolitre	-	-	-	35·317	cubic feet
Myrialitre	-	-	-	353·171	" "

Weights.

French.				*English.*
Milligramme -	-	-	0·0154 grains	
Centigramme	-	-	0·1543 "	
Décigramme -	-	-	1·5434 "	
Gramme -	-	-	15·434 "	
Décagramme -	-	-	154·34 "	
Hectogramme	-	-	3·527 oz. Avoirdupois	
Kilogramme -	-	-	2·2048 lbs.	"
Myriagramme	-	-	22·048 "	"
Quintal -	-	-	1 cwt. 3 qrs. 24 lbs.	"
Millier, or bar	-	9 tons 16 cwt. 3 qrs. 12 lbs.		"
Gramme -	-	-	·0022 lbs.	"

MENSURATION OF SUPERFICIES AND SOLIDS.

To find the Circumference of a Circle.

Multiply the diameter by 3·1416.

To find the Area of a Circle.

Square the diameter and multiply by ·7854. *Example:*—What is the area of a circle 20 feet in diameter? $20 \times 20 \times {\cdot}7854 = 314{\cdot}16$.

To find the Area of a Sector of a Circle.

Multiply the radius by half the arc of the sector for the area, or multiply the whole diameter by the whole arc of the sector, and take one-fourth of the product.

To find the Area of a Segment of a Circle.

Find the area of the sector, having the same arc with the segment. Find also the area of the triangle formed by the chord of the segment and the two radii of the sector, then add these together for the answer when the segment is greater than a semicircle, or subtract them when it is less than a semi-circle.

To find the Area of an Ellipsis, or Oval.

Multiply the longest diameter by the shortest, then multiply the product by ·7854 for the area.

Note.—The circumference of an Ellipsis is $\sqrt{\overline{D^2 + D^2 \times 1{\cdot}11}}$ nearly.

To find the Solidity of a Sphere, or Globe.

Multiply the surface by the diameter, and take one-sixth of the product; or multiply the square of the diameter by the circumference, and take one-sixth of the product.

2nd. Take the cube of the diameter and multiply by ·5236.

3rd. Cube the circumference and multiply by ·01688.

The diameter of a circle multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

The square of the diameter of a cylinder multiplied by its length and divided by any other required length, the square root of the quotient equals the diameter of another cylinder of equal contents or capacity.

The square root of the area of a circle multiplied by 1·12837 equals its diameter.

The diagonal of a square equals the square root of twice the square of its side. The side of a square equal to the diagonal of a given square contains double the area of the given square.

Huddersfield and London.

Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.	Dia.	Area.
⅛	·01227	8½	56·74	17¾	247·45	27	572·55	36¼	1032·	45½	1625·9	54¾	2354·2	64	3216·9	73¼	4214·1	90	6361·7	127	12667·7
¼	·0490	8¾	60·13	18	254·46	27¼	583·20	36½	1046·3	45¾	1643·8	55	2375·8	64¼	3242·1	73½	4242·9	91	6503·8	128	12867·6
⅜	·1104	9	63·61	18¼	261·58	27½	593·95	36¾	1060·7	46	1661·9	55¼	2397·4	64½	3267·4	73¾	4271·8	92	6647·6	129	13069·8
½	·1963	9¼	67·20	18½	268·80	27¾	604·80	37	1075·2	46¼	1680·	55½	2419·2	64¾	3292·8	74	4300·8	93	6792·9	130	13273·2
⅝	·3067	9½	70·88	18¾	276·11	28	615·75	37¼	1089·7	46½	1698·2	55¾	2441·	65	3318·3	74¼	4329·9	94	6939·7	131	13478·2
¾	·4417	9¾	74·66	19	283·52	28¼	626·79	37½	1104·4	46¾	1716·5	56	2463·	65¼	3343·8	74½	4359·1	95	7088·2	132	13684·8
⅞	·6013	10	78·54	19¼	291·03	28½	637·94	37¾	1119·2	47	1734·9	56¼	2485·	65½	3369·5	74¾	4388·4	96	7238·2	133	13892·9
1	·7854	10¼	82·51	19½	298·64	28¾	649·18	38	1134·1	47¼	1753·4	56½	2507·1	65¾	3395·3	75	4417·8	97	7389·8	134	14102·4
1¼	1·227	10½	86·59	19¾	306·35	29	660·52	38¼	1149·	47½	1772·	56¾	2529·4	66	3421·2	75¼	4447·3	98	7542·9	135	14313·9
1½	1·767	10¾	90·76	20	314·16	29¼	671·95	38½	1164·1	47¾	1790·7	57	2551·7	66¼	3447·1	75½	4476·9	99	7697·9	136	14526·4
1¾	2·405	11	95·03	20¼	322·06	29½	683·49	38¾	1179·3	48	1809·5	57¼	2574·1	66½	3473·2	75¾	4506·6	100	7854·	137	14741·1
2	3·141	11¼	99·40	20½	330·06	29¾	695·12	39	1194·5	48¼	1828·4	57½	2596·7	66¾	3499·3	76	4536·4	101	8011·8	138	14956·8
2¼	3·976	11½	103·86	20¾	338·16	30	706·86	39¼	1209·9	48½	1847·4	57¾	2619·3	67	3525·6	76¼	4566·3	102	8171·3	139	15174·7
2½	4·908	11¾	108·43	21	346·36	30¼	718·69	39½	1225·4	48¾	1866·5	58	2642·	67¼	3552·	76½	4596·3	103	8332·3	140	15393·8
2¾	5·939	12	113·09	21¼	354·65	30½	730·61	39¾	1240·9	49	1885·7	58¼	2664·9	67½	3578·4	76¾	4626·4	104	8494·8	141	15614·5
3	7·068	12¼	117·85	21½	363·05	30¾	742·64	40	1256·6	49¼	1905·	58½	2687·8	67¾	3605·	77	4656·6	105	8659·	142	15836·8
3¼	8·295	12½	122·71	21¾	371·54	31	754·76	40¼	1272·3	49½	1924·4	58¾	2710·8	68	3631·6	77¼	4686·9	106	8824·7	143	16060·6
3½	9·621	12¾	127·67	22	380·13	31¼	766·99	40½	1288·2	49¾	1943·9	59	2733·9	68¼	3658·4	77½	4717·3	107	8992·	144	16286·
3¾	11·044	13	132·73	22¼	388·82	31½	779·31	40¾	1304·2	50	1963·5	59¼	2757·1	68½	3685·2	77¾	4747·7	108	9160·9	145	16513·
4	12·566	13¼	137·88	22½	397·60	31¾	791·73	41	1320·2	50¼	1983·1	59½	2780·5	68¾	3712·2	78	4778·3	109	9331·3	146	16741·2
4¼	14·186	13½	143·13	22¾	406·49	32	804·24	41¼	1336·4	50½	2002·9	59¾	2803·9	69	3739·2	78¼	4809·	110	9503·3	147	16971·7
4½	15·904	13¾	148·48	23	415·47	32¼	816·86	41½	1352·6	50¾	2022·8	60	2827·4	69¼	3766·4	78½	4839·8	111	9676·9	148	17203·2
4¾	17·720	14	153·93	23¼	424·55	32½	829·57	41¾	1369·	51	2042·8	60¼	2851·	69½	3793·6	78¾	4870·7	112	9852·	149	17436·6
5	19·635	14¼	159·48	23½	433·73	32¾	842·39	42	1385·4	51¼	2062·9	60½	2874·7	69¾	3821·	79	4901·6	113	10028·	150	17671·5
5¼	21·64	14½	165·13	23¾	443·01	33	855·30	42¼	1401·9	51½	2083·	60¾	2898·5	70	3848·4	79¼	4932·7	114	10207·	160	20106·2
5½	23·75	14¾	170·87	24	452·39	33¼	868·30	42½	1418·6	51¾	2103·3	61	2922·4	70¼	3875·9	79½	4963·9	115	10386·9	170	22698·
5¾	25·96	15	176·71	24¼	461·86	33½	881·41	42¾	1435·3	52	2123·7	61¼	2946·4	70½	3903·6	79¾	4995·1	116	10568·	180	25446·9
6	28·27	15¼	182·65	24½	471·43	33¾	894·61	43	1452·2	52¼	2144·1	61½	2970·5	70¾	3931·3	80	5026·5	117	10751·	190	28352·9
6¼	30·67	15½	188·69	24¾	481·10	34	907·92	43¼	1469·1	52½	2164·7	61¾	2994·7	71	3959·2	81	5153·	118	10935·9	200	31416·
6½	33·18	15¾	194·82	25	490·87	34¼	921·32	43½	1486·1	52¾	2185·4	62	3019·	71¼	3987·1	82	5281·8	119	11122·	210	34636·
6¾	35·78	16	201·06	25¼	500·74	34½	934·82	43¾	1503·3	53	2206·1	62¼	3043·4	71½	4015·1	83	5410·6	120	11309·7	220	38013·
7	38·48	16¼	207·39	25½	510·70	34¾	948·41	44	1520·5	53¼	2227·	62½	3067·9	71¾	4043·2	84	5541·7	121	11499·	230	41547·
7¼	41·28	16½	213·82	25¾	520·76	35	962·11	44¼	1537·8	53½	2248·	62¾	3092·5	72	4071·51	85	5674·5	122	11689·6	240	45239·
7½	44·17	16¾	220·35	26	530·93	35¼	975·90	44½	1555·2	53¾	2269·	63	3117·2	72¼	4099·8	86	5808·9	123	11882·3	250	49087·
7¾	47·17	17	226·98	26¼	541·18	35½	989·80	44¾	1572·8	54	2290·2	63¼	3142·	72½	4128·2	87	5944·6	124	12076·	...	...
8	50·26	17¼	233·70	26½	551·54	35¾	1003·7	45	1590·4	54¼	2311·	63½	3166·9	72¾	4156·7	88	6082·1	125	12271·8	...	...
8¼	53·45	17½	240·52	26¾	562·	36	1017·8	45¼	1608·1	54½	2332·	63¾	3191·9	73	4185·3	89	6221·1	126	12468·8	...	...

TABLE OF CONSTANT NUMBERS BY WHICH THE WEIGHT OF A PATTERN CAN BE MULTIPLIED TO FIND THE WEIGHT OF A CASTING IN THE FOLLOWING METALS.

Pattern made of	Cast Iron.	Brass.	Red Metal.	Bronze.	Bell Metal.	Cannon Metal.	Zinc.
Pine wood ...	14·0	15·8	16·7	16·3	17·0	17·1	13·5
Oak	9·0	10·1	10·4	10·3	10·8	10·9	8·6
Beech	9·7	10·9	11·4	11·3	11·8	11·6	9·4
Pear Tree ...	10·2	11·5	11·9	11·8	12·3	12·4	9·8
Birch	10·6	11·9	12·3	12·2	12·8	12·9	10·2
Alder	12·8	14·3	14·9	14·7	15·4	15·5	12·2
Mahogany ...	11·7	13·2	13·7	13·5	14·1	14·2	11·2
Brass	0·84	0·95	0·99	0·98	1·02	1·03	0·81
Zinc...	1·00	1·13	1·17	1·16	1·21	1·22	0·96
Tin	0·89	1·00	1·03	1·03	1·07	1·08	0·85
Lead	0·64	0·72	0·74	0·74	0·77	0·78	0·61
Cast Iron ...	0·97	1·09	1·13	1·12	1·17	1·18	0·93

THERMOMETERS.

In Europe there are three different kinds of thermometers used :—

1. Fahrenheit's, in Britain and Holland, also North America; freezing point is at 32°, and boiling point 212°.
2. Reaumur's, used in Spain and other continental states; freezing point, or zero, 0°, and boiling point 80°.
3. Celsius, or Centigrade, almost universally used on the Continent; zero, or freezing point, 0°, and boiling point 100°.

Rule 1. Multiply the Centigrade degrees by 9 and divide the product by 5 ; or multiply the degrees of Reaumur by 9 and divide the product by 4; then add 32 to the quotient in either case, and the sum is the degrees of Fahrenheit.

Rule 2. From the number of degrees on Fahrenheit's scale subtract 32, multiply the remainder by 5 for Centigrade degrees, or 4 for Reaumur's degrees, and the product in either case being divided by 9 will give the temperature required.

W. C. Holmes & Co., Huddersfield & London.

TABLE OF VALUES OF DIFFERENT FUELS.

Species of Fuel.	Effect in pounds of Water heated 1 degree by 1 lb. of fuel.	Effect in pounds of Water converted into Steam of 220.	Quantity required to convert a cubic foot of Water into low pressure Steam.	Quantity required to convert a cubic foot of Water into Steam, allowing 10 per cent. for loss.
Olive Oil	13700	11·7	5·3	5·89
Caking Coal	9800	8·4	7·45	8·22
Splint Coal	7900	6·75	9·25	10·28
Staffordshire Coal	7500	6·4	9·75	10·83
Coke prepared in Close Vessels	9000	7·7	8·1	9·00
Oak Wood (dry)...	6000	5·13	12·2	13·6
Charred Peat	5670	4·85	12·9	14·3
Peat, compact and dry	3900	3·35	18·7	20·8
Ordinary Oak	3600	3·07	20·31	22·6
Peat, compact, in ordinary state of dryness	3250	2·08	22·5	25·0

TABLES OF PROPERTIES OF THE STEAM OF WATER OF DIFFERENT DEGREES OF ELASTIC FORCE.

Total Force of Steam.			Excess of Force above the Atmosphere.		Temperature in degrees of Fahrenheit.	Volume in cubic feet, Water being 1	Weight of a cubic foot in grains.	Specific Gravity, Air being 1	Velocity into a vacuum in feet, per second.	Heat of conversion from Water of 52° to Steam.
In Atmospheres.	In inches of Mercury.	In pounds per circular inch.	In pounds per circular inch.	In pounds per square inch.						Dgs.
·0183	·55	·21	—11·33	—14·4	60	72190	6·1	·0115	1377	1800
·0333	1	·385	—11·155	—14·2	77	41010	10·7	·0202	1400	1025
·0667	2	·77	—10·77	—13·7	98·7	21400	20·5	·0388	1427	1047
·1	3	1·15	—10·39	—13·2	112·5	14570	30	·0568	1445	1061
·1333	4	1·54	—10·	—12·7	123	11130	39	·0744	1458	1071
·25	7·5	2·88	— 8·66	—10·99	147·6	6187	71	·134	1499	1096
·5	15	5·77	— 5·77	— 7·33	178	3249	135	·255	1526	1126
·75	22·5	8·65	— 2·89	— 3·66	197·4	2232	196	·371	1549	1146
1·00	30	11·54	— 0	— 0	212	1711	254·7	·484	1566	1160
1·17	35	13·46	1·92	2·44	220	1497	292	·553	1575	1168
1·5	45	17·31	5·77	7·33	233·8	1178	363	·687	1591	1182
1·75	52·5	20·19	8·65	10·99	242·5	1022	427	·81	1601	1191
2·0	60	23·08	11·54	14·65	250·2	905	483	·915	1610	1199
2·5	75	28·85	17·31	21·98	263·5	787	593	1·123	1625	1212
3·0	90	34·62	23·08	29·3	274·7	623	700	1·33	1638	1223
3·5	105	40·39	28·85	36·63	284·5	542	810	1·53	1649	1233
4·0	120	46·16	34·62	43·95	293·1	479	910	1·728	1658	1241
5	150	57·7	46·15	58·60	308	391	1110	2·12	1674	1256
6	180	69·24	57·7	73·25	320·6	331	1317	2·5	1688	1269
7	210	80·78	69·24	87·90	331·5	288	1520	2·88	1700	1280
8	240	92·32	80·78	102·55	341·2	255	1660	3·25	1710	1289
9	270	103·86	92·32	117·20	350	229	1910	3·61	1720	1298
10	300	115·4	103·86	131·85	358	209	2100	3·97	1729	1306
20	600	230·8	219·26	278·35	414	111	3940	7·44	1786	1362
30	900	346·2	334·66	424·85	450	77	5670	10·75	1823	1398
40	1200	461·6	450·06	571·75	477	60	7350	13·88	1850	1425

W. C. Holmes & Co.,

With boilers of ordinary construction 1 lb. of coal is required to raise the temperature of $3\frac{1}{3}$ gallons of water from 32° to the boiling point; 5 lbs. of coal will convert the same quantity at the boiling point into steam; therefore, 6 lbs. of coal will convert 32 lbs. of water at 32° into steam; but in boilers of the best construction these results are nearly doubled.

TABLE OF COMMERCIAL DISCOUNTS.

Per Cent.	In the £. s. d.	In the Shilling. s. d.	Per Cent.	In the £. s. d.	In the Shilling. s. d.
⅛	0 0 3/10	0 0 3/200	30	6 0	0 3 3/5
¼	0 0 3/5	0 0 3/100	31¼	6 3	0 3 3/4
½	0 1 1/5	0 0 3/50	32½	6 6	0 3 9/10
¾	0 1 4/5	0 0 9/100	33¾	6 9	0 4 1/20
1	0 2 2/5	0 0 6/50	35	7 0	0 4 1/5
1¼	0 3	0 0 3/20	36¼	7 3	0 4 7/20
2½	0 6	0 0 3/10	37½	7 6	0 4 1/2
3¾	0 9	0 0 9/20	38¾	7 9	0 4 13/20
5	1 0	0 0 3/5	40	8 0	0 4 4/5
6¼	1 3	0 0 3/4	41¼	8 3	0 4 19/20
7½	1 6	0 0 9/10	42½	8 6	0 5 1/10
8¾	1 9	0 1 1/20	43¾	8 9	0 5 1/4
10	2 0	0 1 1/5	45	9 0	0 5 2/5
11¼	2 3	0 1 7/20	46¼	9 3	0 5 11/20
12½	2 6	0 1 1/2	47½	9 6	0 5 7/10
13¾	2 9	0 1 13/20	48¾	9 9	0 5 17/20
15	3 0	0 1 4/5	50	10 0	0 6
16¼	3 3	0 1 19/20	55	11 0	0 6 3/5
17½	3 6	0 2 1/10	60	12 0	0 7 1/5
18¾	3 9	0 2 1/4	65	13 0	0 7 4/5
20	4 0	0 2 2/5	70	14 0	0 8 2/5
21¼	4 3	0 2 11/20	75	15 0	0 9
22½	4 6	0 2 7/10	80	16 0	0 9 3/5
23¾	4 9	0 2 17/20	85	17 0	...
25	5 0	0 3	90	18 0	...
26¼	5 3	0 3 3/20	95	19 0	...
27½	5 6	0 3 3/10	100	20 0	...
28¾	5 9	0 3 9/20			

Huddersfield and London.

NOTES ON BUILDING WORK.

One rod of brickwork contains 272 feet superficial, reduced to the thickness of 1½ bricks, or 13½ inches; or 306 cubic feet, or 408 feet superficial of one brick, or 9 inches in thickness; or 4,300 stock bricks in mortar, or 4,750 ditto laid dry; and requires 3 cubic yards of drift and 27 bushels of chalk lime, or 3½ loads of sand and 18 bushels of stone lime, or 36 bushels of sharp sand and 36 bushels of cement. A load of mortar measures 27 cubic feet, and requires 1 cubic yard of sand and 9 bushels of lime, and will fill 30 hods.

A bricklayer's hod measuring $16 \times 9 \times 9$ inches, equals 1,296 inches in capacity, and contains 20 bricks.

A load of sand and other materials equals 27 cubic feet. A measure of lime is a single load, or a cube yard, and contains 21 striked bushels. 1,000 bricks, closely stacked, occupy about 56 cube feet, and 1,000 old bricks, cleaned and loosely stacked, occupy about 72 cube feet.

One foot superficial of reduced work (13½ inches) requires 16 bricks, and one foot of gauged arches 10 bricks.

A bricklayer and labourer will lay about 1,000 bricks per day.

A rod of brickwork, laid 4 courses to gauge 12 inches, contains 235 cubic feet of bricks and 71 cube feet of mortar, and weighs about 15 tons.

Lime and sand, and likewise cement and sand, lose one-third of their bulk when made into mortar.

Lime, or cement and sand to make mortar, require as much water as is equal to one-third of their bulk.

A cubic yard of concrete requires 34 cube feet of material; or if the gravel is to the lime as 6 to 1, a cube yard of concrete will require 1·1 cube yards of gravel and sand, and 3 bushels of lime.

Brick nogging, per superficial yard, requires 30 bricks on edge, or 45 laid flat.

One yard of paving requires 36 stock bricks laid flat, or 52 on edge.

W. C. Holmes & Co.,

SIZES AND WEIGHTS OF VARIOUS ARTICLES.

Name of Article.	Length.	Breadth.	Thickness.	Weight.
Stock Bricks	8¾ inches.	4¼ inches.	2½ inches.	5 lbs.
Paving Do.	9 „	4½ „	1¾ „	4 „
Dutch Clinkers	6¼ „	3 „	1½ „	1½ „
12-in. Paving Tiles	11¾ „	11¾ „	1½ „	13 „
10-in. Do.	9¾ „	9¾ „	1 „	8 lbs. 9 oz.
Pantiles	13½ „	9½ „	½ „	5 „ 4 „
Plain Tiles	10½ „	6½ „	⅝ „	2 „ 5 „
Pantile Laths, per 10-ft. bundle	120 feet	1½ „	1 „	4 „ 6 „
Do. 12-ft. „	144 „	1½ „	1 „	5 „ 0 „
Plain Tile Laths, per bundle (A Bundle contains 12 Laths, 30 Bundles Laths make a Load.)	500 „	1 „	¼ „	3 „ 0 „

TABLE OF SIZES OF ROOFING SLATES.

	Length.	Breadth.	Average gauge in inches.	Number required to cover one square.	Weight per 1200 in tons.	Number of Nails required to one square.
Doubles	13 inches	6 inches	5½	480	¾	480
Ladies	16 „	8 „	7	280	1¼	280
Countesses ...	20 „	10 „	9	176	2	352
Duchesses ...	24 „	12 „	10½	127	3	254
Imperials... ...	30 „	24 „	A ton will cover 2¼ to 2½ squares.			
Rags and Queens	36 „	24 „	A ton will cover 2¼ to 2½ squares.			
Westmorelands, of various sizes		A ton will cover 2 squares.				

The lap should not be less than 2 inches, and need not exceed 3 inches. The lap being decided on, the gauge will be equal to half the distance from the tail to the nailhole, less the lap. Thus a Countess slate measuring 19 inches from tail to tail, if laid with a 3-inch lap, would show a margin of $\frac{19-3}{2} = 8$.

The battens are nailed on the rafters at the gauge to which the slates will work. If the slates are of different lengths, they must be sorted into sizes, the smallest being placed nearest the ridge.

COMPARATIVE WEIGHT PER SQUARE OF COVERINGS FOR ROOFS.

	cwt.	qrs.	lbs.		cwt.	qrs.	lbs.		cwt.	qrs.	lbs.
Slates (Queens)	7	2	0	+ Wrought Iron Laths	1	2	25	=	9	0	25
Plain Sheet Iron, No. 16 W. G. ...	2	2	20	+ Ditto	1	2	25	=	4	1	17
Corrugated Sheet Iron	3	0	0	+ Ditto	0	3	12	=	3	3	12
Cast Iron Plates, ⅜ thick	13	2	3	... ...					13	2	3
Boarding, 1½ in. thick	4	1	24	+ Pn.Sht.In.No.20W.G.	1	1	18	=	5	3	14

Huddersfield and London.

TABLE OF THE SIZE AND WEIGHT OF IRON LATHS.

Distance apart of principals.		Queens, 27 inches wide. Laths, 12 inches apart.				Princesses and Duchesses, 24 inches wide. Laths, $10\frac{1}{2}$ inches apart.				Countesses, 24 inches wide. Laths, $8\frac{1}{2}$ inches apart.			
Feet.	inches.	Width of each side of Lath.	Thickness of Lath.	Weight per foot.		Width of each side of Lath.	Thickness of Lath.	Weight per foot.		Width of each side of Lath.	Thickness of Lath.	Weight per foot.	
		Inches.	W. G.	lbs.	oz.	inches.	W. G.	lbs.	oz.	inches.	W. G.	lbs.	oz.
5 5	0 6	1¼	No. 8	1	8	1¼	No. 9	1	4	1⅛	No. 9	1	4
6 6	0 6	1⅜	No. 6	1	12	1¼	No. 8	1	8				
7	0	1½	½ inch	2	8	1⅜	No. 6	1	12	1¼	No. 8	1	8

The entire weight of a corrugated roof, curved, per square, from 30 to 40 feet span, is about 2½ cwt., and entire cost 90s. to 100s. per square. If 40 to 60 feet span, the weight will be about 3 cwt., and the cost 105s. to 126s. per square. Roofs of smaller span may be made for as low as 60s. per square.

Stability of Chimneys.

Fresnel gives the formula $x = ab \times \frac{c}{2}$, in which x represents the stability which the chimney or column ought to present, a the surface exposed to the action of the wind, b a co-efficient, representing the force of the wind, and $\frac{c}{2}$ the lever with which that force is exerted, or, on the average, half the height. The stability, of course, will be found by multiplying the weight of the structure by half the width of the base; the value of b should be at least equal to 66 lbs.

A square chimney offers one-third more resistance to wind than a round one.

TIMBER.

Oak.

For strength and durability choose that which is slowest of growth; of two pieces equally dry, choose the heavier, and that which will be the least changed by being soaked in water. In similar soils, trees growing next the outside of the forest are more durable than those near the middle; and in the same tree, the side next to the north is the strongest. Trees should be cut during winter, when free from sap. In trees cut before they have passed

their prime, the outward rings, or coats, begin first to decay when exposed to damp situations, but in old trees the decay begins at the central parts. In bad soils there is least sap. In ash there is little difference of quality through the whole thickness; the outside is rather the toughest; it ever rots when exposed to the weather—lasts long when protected.

Timber for Carpentry and Joinery Purposes.

The fir timber in general use is imported from Memel, Riga, Dantzic, and Sweden. Memel timber is the most convenient for size; Riga the best in quality; Dantzic the strongest, and Swedish the toughest. Riga timber can always be depended on; red pine may be used wherever durability and strength are objects, and Quebec yellow pine for light, dry purposes.

In selecting timber, avoid spongy heart, porous grain, and dead knots; choose the brightest in colour, and where the strong red grain appears to rise on the surface.

Deals are from Norway, Sweden, Prussia, and Russia. For framing, the best deals are the Norway, particularly the Christiania battens; for panelling, the Christiania white deals; for ground-floors, Stockholm and Gefle yellows; for upper floors, Drom and Christiania whites; for warehouse floors and staircases, Archangel and Onega planks; and for best floors, &c., Petersburg, Onega, and Christiania battens.

ADHESION OF NAILS OF VARIOUS KINDS DRIVEN INTO DRY DEAL AT RIGHT ANGLES TO THE GRAIN OF THE WOOD.

Description of nails used.	Number to the lb.	Inches long.	Inches forced into the wood.	lbs. required to extract.	Description of nails used.	Number to the lb.	Inches long.	Inches forced into the wood.	lbs. required to extract.
Fine sprigs ...	4560	0·44	0·40	22	6d. nails ...	73	2·50	1·00	187
Ditto ...	3200	0·53	0·44	37	Ditto ...	„	„	1 50	327
3d. brads ...	618	1·25	0·50	58	Ditto ...	„	„	2·00	530
Cast Iron nails	380	1·00	0·50	72	5d. nails ...	139	2·00	1·50	320

By experiments which have been made, the percussive force required to drive the common 6d. nail to the depth of $1\frac{1}{2}$ in. into dry deal, with a cast iron weight of $6\frac{1}{4}$ lbs., was 4 blows falling freely the space of 12 in., and the steady pressure to produce the same was 400 lbs. A 6d. nail driven into dry elm to the depth of 1 in. across the grain required a pressure of 327 lbs. to extract it; the same nail driven endways into the same wood was extracted by 257 lbs.; the relative proportion, therefore, is 100 to 78. The progressive depths of a 6d. nail into dry deal by simple pressure were as follows:—$\frac{1}{4}$ in., a pressure of 24 lbs.; $\frac{1}{2}$ in., a pressure of 76 lbs.; 1 in., a pressure of 235 lbs.; $1\frac{1}{2}$ in., a pressure of 400 lbs.; 2 in., a pressure of 610 lbs.

To extract a 6d. nail from a depth of 1 in. out of dry oak, required 507 lbs.; dry beech, ditto, 667 lbs.; green sycamore ditto, 312 lbs.

The cohesive power of glue has been found to be about 4,000 lbs. per square inch.

The cohesive power of red sealing-wax has been found to be about 1,500 lbs. per square inch.

The cohesive power of black sealing-wax has been found to be about 1,000 lbs. per square inch.

Mr. Bevan found that when two cylinders of dry ash, $1\frac{1}{2}$ inch in diameter, were glued together and, after 24 hours, torn asunder, it required a force of 1,260 lbs. for that purpose; the force of adhesion was consequently 715 lbs. per square inch.

PRESSURE OF WATER AGAINST WALLS, SIDES OF TANKS, &c.

A = Area of surface pressed, in feet,

H = Depth of centre of gravity below surface, in feet.

Then,

$$\text{Pressure in lbs.} = 62\tfrac{1}{2}\ A\ H.$$

The pressure may be considered as acting at a point two-thirds of the total depth from the top.

W. C. Holmes & Co., Huddersfield & London.

TABLES OF SPECIFIC GRAVITY.

Barometer 30 in., Thermometer 60° Fahrenheit.

Gases.

Atmospheric Air	1·0000	Mercurial Gas	6·976
Hydrogen	0·0694	Anhydrous Sulphuric Acid..	3·000
Nitrogen	0·9691	Camphor	5·468
Oxygen	1·1111	Benzoin	2·77
Ammoniacal Gas	0·5902	Naphthaline	4·528
Carburetted Hydrogen ...	0·9722	Alcohol	1·6133
Sulphuretted ditto... ...	1·192	Ether	2·586
Carbonic Oxide	0 972	Acetic Ether	3·069
Carbonic Acid	1·5196	Oxalic ditto...	5·087
Sulphuret of Carbon ...	2·644	Benzoic ditto	5·409
Aqueous Vapour in contact with water at 212° ...	0·484	Sulphate of Methylene ...	4·565
		Acetate of ditto	2·563
Muriatic Acid Gas... ...	1·2847	Bichloride of Tin	9·199
Nitrous Oxide	1·5277	Sulphate of Mercury ...	5·5
Cyanogen	1·818	Spirits of Turpentine ...	4·763
Oil Gas	2·7	Cacodyle	7·1
Naphtha ditto	2·833	Oxide of ditto	7·55
Oil of Turpentine ditto ...	5·013	Potass.Oil	3·147
Chlorine	2·5082	Acetone	2·019
Iodine Vapour	8·678	Essence of Bitter Almonds..	3·708
Nitric Acid	1·218	Selenitic Acid	4·030
Sulphuric ditto	2·777	Hypo-azotic ditto	1·720
Euchlorine Gas	2·365	Protochloride of Phosphorus	4·87
Prussic Acid ditto	0·937	Valeric Acid	3·68
Acetic Acid ditto	2·77	Alcehyde	1·532
Benzoic Acid ditto... ...	4·27	Protochloride of Mercury ...	8·35
Bromine Vapour	5·540	Bichloride of ditto	9·80
Sulphur ditto	6·617	Arsenical Acid	13·850
Phosphorus ditto	4·420	Chloride of Arsenic ...	6·60
Arsenical Gas	10·600	Iodide of ditto	16·10

Liquids.

Water, distilled	1000	Milk, Ewe's...	1040·9
Ditto at 212°. distilled ...	956·2	Linseed Oil	932
Ditto at 35°, maximum of density	1000·9	Olive ditto	913
		Whale ditto	923
Sea Water	1026	Hempseed ditto	926
Naphtha	708	Oil of Cinnamon	1043
Alcohol, pure	796	Ditto Lavender	894
Ditto of commerce	825	Ditto Amber	868
Tar	1015	Ditto Turpentine, essential..	870
Muriatic Ether	730	Ditto Sweet Almonds ...	932
Nitric ditto	909	Urine	1032
Sulphuric ditto	736	Muriatic Acid	1194
Ammonia	978	Nitric ditto	1217
Spirit of Wine	1120	Sulphuric ditto, pure ...	1848·5
Wine	1038	Ditto, highly concentrated...	2125
Brandy	927	Fluoric Acid	1060
Beer...	1034	Citric ditto	1034
Ale, Pale	1023	Acetic ditto	1062
Cider	1018	Proof Spirit...	922
Vinegar	1026	Treacle	1290
Aqua Regia...	1234	Common Air	·0013
Milk, Woman's	1020	Or, 800 times lighter than Water.	
Ditto, Cow's	1032		

TABLES OF SPECIFIC GRAVITY—(*continued.*)

Gums, Animal Substances, &c.

Water	1000	Gum, Euphorbia	1124
Indigo	769	Ditto, Ammoniac	1207
Fat Beef	923	Ditto, Aleppo	1235
Butter	942	Ditto, Tragacanth	1316
Spermaceti	943	Ditto, Arabic	1452
Lard...	948	Gamboge	1222
Bees'-wax, yellow	965	Guaiacum	1229
Ditto, white...	969	Assafœtida	1328
Camphor	989	Opium	1336
Blood, serum of human ...	1028	Aloes, hepatic	1359
Copal, Madagascar... ...	1060	Ditto, socotrine	1380
Mastic	1074	Myrrh	1360
Tallow	943	Honey	1450
Pitch	1150	Sugar	1600
Ivory	1826	Petroleum	750

Earths, Stones, &c.

Water	1000	Marble, white Parian ...	2838
Pumice Stone	915	Crystal, Brazil	2653
Ambergris	780 to 926	Granite, Egyptian	2654
Gunpowder...	932	Slate, common	2672
Amber, yellow	1078	Porphyry, green	2676
Bitumen, India	1104	Alabaster, Piedmont ...	2693
Cannel Coal...	1270	Beryl, occidental	2723
Slate Coal, English... ...	1370	Emerald, Peru	2775
Phosphorus	1714	Chalk, British	2657 to 2784
Nitre	1900	Talc, Muscovy	2792
Brick	2000	Basalt, Irish	2864
Stone, siliceous	2143	Hone, white razor	2876
Ditto, paving	2462	Arragonite	2946
Ditto, Portland	2496	Lapis Lazuli	2767 to 3051
Limestone, white fluor ...	3156	Sapphire, Brazilian... ...	3131
Sulphur, native	2033	Barytes, Sulphate of ...	4484
Opal, precious	2114	Copper pyrites	4950
Gypsum, opaque	2168	Iron ditto	3900
Ditto, transparent	2274	Onyx	2600
Stalactite	2324	Sardonyx	2604
Obsidium	2348	Alum	1714
Jasper, green	2359	Diamond, Brazil	3441
Porcelain	2385	Ruby	3536
Spar, transparent	2564	Topaz	3530
Asbestos, ripe	2578	Hornblende, common ...	3600 to 3837
Flint, black...	2582	Hyacinth	3680
Agate	2590	Garnet, Syria	4000
Carnelian	2623	Vermilion	4230
Serpentine	2594	Amethyst	2700
Pebble, English	2609	Schoerl	3600
Chalcedony	2616	Tourmaline	3000
Glass, green...	2642	Fluor	3500
Ditto, white...	2892	Lapis Calaminaris	5000
Quartz, milky	2652	Chrysolite	3700
Marble, Sienna	2678		

TABLES OF SPECIFIC GRAVITY—(*continued.*)

Woods.

Water	1000	Ash, white	800
Cork...	240	Ditto, black...	812
Poplar	383	Acacia	860
White Pine...	426	Alder	800
Yellow ditto, Canada ...	440	Yew...	790
Red ditto, ditto	536	Deal...	460
Pitch ditto, Baltimore ...	632	Laburnum	920
Riga Fir	479	Hawthorn	910
Spruce ditto, Canada ...	518	Holly	760
Fir, Scotch	696	Maple, hard	755
Sassafras	482	Apple-tree	793
Larch, Scotch	530	Mahogany	637 to 1063
Pear-tree	650	Yellow Wood, Africa ...	643
Plum-tree	755	Teak...	666
Willow	585	Walnut-tree	671
Elm, English	588 to 800	Elder	695
Sallow	700	Beech	852
Lime, or Linden-tree ...	604	Box, French	912
Sycamore	690	Olive	927
Cedar, Palestine	613	Logwood	931
Oak, American	900	Ebony	1177
Ditto, English	743 to 760	Vine...	1327
Heart of Oak, 60 years old...	1170	Box, Dutch...	1328
Lignum Vitæ	1333	Damson	790
Birch	640	Lancewood	1010
Cane...	400	Mulberry	660
Chestnut	610		

Metals.

Water	1000	Tin, Cornish, pure	7291
Sodium	865	Ditto, hardened	7299
Potassium	972	Nickel	7807
Plumbago	1987 to 2267	Cobalt	7812
Arsenic, glass of	3594	Brass, cast	7824
White Lead	4059	Ditto, wire-drawn	8544
Antimony, crude	4064	Bismuth, native	9020
Molybdenum	4738	Ditto, molten	9823
Manganese	4756	Mercury, brown	10218
Loadstone	4800	Ditto, fluent	13568
Copper, Cornwall	5452	Ditto, congealed	15630
Ditto, native	7600 to 7800	Ditto, red precipitate ...	8399
Ditto, wire-drawn	8878	Silver, native	10000
Tungsten	6066	Ditto, virgin, hammered ...	10511
Litharge	6300	Gold, not hammered ...	15709
Uranium	6440	Ditto, hammered	15775
Zinc, in common state ...	6862	Ditto, standard, 22 carats...	18888
Ditto, compressed	7191	Pure Gold	19258
Iron, cast	7200	Platinum, purified ...	19500
Bar Iron	7600 to 7788	Ditto, hammered	20336
Steel, tempered	7818	Ditto, wire-drawn	21041
Ditto, not tempered ...	7833	Ditto, compressed by rolling	22069

TABLE OF THE COMBUSTION, TEMPERATURE, AND EXPLOSIVE POWER OF GASES.—*Letheby.*

Gas.	Cubic feet of Air raised 1° by one cubic foot of Gas.	Results of Combustion per lb. of substance.			Pounds of Water heated 1° Fahr.			Temperature of Combustion.				Explosive power.		Mechanical Power per lb. in tons.	Gas.
								Open Flame.		Closed Vessel.					
		Oxygen used.	Carbonic acid produced.	Air vitiated.	Per lb. substance.	Per c. ft. of substance.	Pr. lb. of Oxygen used.	With Oxygen.	With Air.	With Oxygen.	With Air.	With Oxygen.	With Air.	Raised one foot high.	
	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	lbs.	lbs.	lbs.	Degrees.	Degs.	Degrees.	Degs.	Atmospheres.	Atmospheres.	Tons.	
Hydrogen	15837	93·4	0·0	467	62030	329	7754	14510	5744	19035	7852	25·6	12·5	21390	Hydrogen
Marsh Gas	47946	47·2	23·6	826	23513	996	5878	14130	4762	18351	6680	37·0	14·0	8108	Marsh Gas
Olefiant Gas	76299	40·5	27·0	878	21344	1585	6225	16535	5217	21344	7200	42 9	15·1	7360	Olefiant Gas
Propylene	114378	40·5	27·0	878	21327	2376	6220	16522	5239	21327	7177	67·3	22·5	7360	Propylene
Butylene	152502	40·5	27·0	878	21327	3168	6220	16522	5232	21327	7177	85·8	30·2	7360	Butylene
Acetylene	60220	36·3	29·1	909	18197	1251	5914	17146	5142	22006	7009	37·9	17·6	6275	Acetylene
Benzole	185814	36·3	29·1	909	18197	3860	5915	17146	5142	22006	7009	113·7	52·8	6275	Benzole
Carbonic Oxide	15403	6·7	13 5	371	4325	320	7569	12719	5358	16173	7225	21·8	11·7	1490	Carbonic Oxide
Bisulphd. of Carbn.	...	14·9	5·0	689	6120	1239	4845	15280	4314	20031	5917	30·2	11·6	2110	Bisulphid. of Carbn.
Sulphretd. Hydrgn.	...	16·7	0·0	630	7444	671	5271	13688	4388	17542	6026	28·3	12 7	2567	Sulphrettd. Hydrgn.
Cyanogen	...	14·5	14·5	435	6712	925	5142	13488	5028	17645	6167	35·6	17·8	2314	Cyanogen
Common Coal Gas	31290	37·5	17·6	618	21060	650	6816	14320	5228	18101	7001	29·2	14·6	7262	Common Coal Gas
Cannel Gas	36585	31·0	22·0	698	20140	760	6503	14826	5121	19046	7186	38·8	18·0	6945	Cannel Gas
Wood Spirit	...	25·3	11·8	422	9547	819	6363	11435	4641	14902	6347	40·3	15·3	3290	Wood Spirit
Alcohol	...	24·6	16·4	533	12929	1597	6195	13305	4831	17223	6629	46·4	16·1	4455	Alcohol
Ether	...	30·9	20·4	664	16249	3217	6158	14874	5150	19225	6953	58·6	19·0	5603	Ether
Camphine	...	38·9	27·8	880	19573	7134	5942	16271	5026	20953	6922	47·6	16·0	6750	Camphine
Spermaceti	...	37·0	25·2	815	17589	...	6088	14599	4413	...	...	...	...	6065	Spermaceti
Wax	...	37·7	25·6	829	15809	...	4995	12921	4122	...	...	...	...	5451	Wax
Stearic Acid	...	34·6	24·0	783	17050	...	6061	15885	4818	...	...	...	...	5880	Stearic Acid
Stearine	...	34.4	14·2	527	18001	...	6143	15815	5095	...	...	...	...	6207	Stearine
Paraffine	...	40·5	27·0	878	21327	...	6220	16522	5239	...	...	...	...	7354	Paraffine
Paraffine Oil	...	40·5	27·0	878	21327	...	6220	16522	5239	...	...	...	...	7354	Paraffine Oil
Rape Oil	...	38·7	24·3	801	17752	...	6123	15830	5087	...	...	...	...	6121	Rape Oil
Sperm Oil	...	38·7	24·3	801	17230	...	6088	15363	4937	...	...	...	...	5941	Sperm Oil
Carbon	...	31·0	31·5	943	14544	...	5447	18329	3026	...	...	...	...	5015	Carbon

GENERAL INDEX.

Huddersfield and London.

W. C. Holmes & Co.,

Huddersfield and London.

W. C. Holmes & Co.,

peculiarity connected with this Condenser is that the annular space is divided by a vertical partition, on one side of which the Gas rises and descends on the other side; the Gas is thus more uniformly spread over the cooling surface than in the case of the ordinary Condenser.

The Combined Coal and Oil Gas Apparatus is arranged specially for lighting noblemen's and gentlemen's mansions, &c.; the Coal Gas being applied to the lighting of stables, out-offices, kitchens, and servants' rooms generally, &c., the Oil Gas being used for the best rooms, main corridors, staircases, &c.

By this arrangement, the Oil Gas costs no more (light for light) than the Coal Gas, whilst from its purity and freedom from sulphur compounds, it may be admitted into picture-galleries, libraries, &c.

Their new and improved process of manufacturing Gas (recently patented) has for its object the obtaining, and utilising, or converting into Gas, a much larger proportion of the volatile matter contained in the Coal, the Gas thus produced being larger in quantity and of greater illuminating power than can be obtained by the ordinary methods. The Coke also is of greater value, on account of its being deprived of its sulphur, which renders it peculiarly eligible for consumption in public establishments, private houses, &c.

Messrs. W. C. Holmes & Co. also supply all descriptions of Apparatus in detail, required in the Manufacture, Distribution and Consumption of Gas, including—

Retorts of iron, clay, and fire-brick, with all the requisite fittings; also fire-bricks, lumps, tiles, and fire-clay for setting.

Condensers, Washers, Scrubbers, Exhausters with engines, boilers, &c., Purifiers, Station Meters, Gasholders, both single-lift and telescopic, with guide-columns, girders, and all the usual fittings, Station Governors, Centre Change Valves, By-pass and Stop Valves, Tar, Water, and Syphon Pumps, Pressure Gauges, Tools, &c., &c. Wrought and Cast Iron Tanks for Gasholders, Iron Framework for Roofs of Buildings, Corrugated and Galvanised Iron Roofs, Iron Retort Houses, Cast Iron Window Frames, &c.

Main and Service Pipes and Fittings, Lamp Columns and Brackets, Lamp Columns to contain a meter in base, Street Lanterns and Fittings, Wet and Dry Consumers' Meters, Regulators, &c.

Further Particulars on application.

W. C. Holmes & Co.,

Darfield (and Wombwell) - -	Yorkshire.
Dalton (Kirkheaton and Lepton) -	Yorkshire.
Didcot - - - -	Berkshire.
Dinsdale (and Middleton) - -	Durham.
Ditchling (Hassock's Gate, Keymer)	Sussex.
Earl's Colne - - -	Essex.
† Earlstown - - - -	Lancashire.
Eston (South Bank and Normanby) -	Yorkshire.
Eynsham - - - -	Oxfordshire.
Felton - - - -	Northumberland.
Finedon - - - -	Northamptonshire.
Fordingbridge - - -	Hampshire.
Garforth - - - -	Yorkshire.
† Gefle - - - -	Sweden.
Goudhurst - - - -	Kent.
Gresley (Newhall, Woodville, Swadlincote) - - - -	Derbyshire.
Haslemere - - - -	Sussex.
Hassock's Gate (Keymer & Ditchling)	Sussex.
Hatfield - - - -	Yorkshire.
Hawkhurst - - - -	Kent.
Hedon - - - -	Yorkshire.
Hirschberg - - - -	Germany.
Hogsthorpe - - - -	Lincolnshire.
† Holyhead - - - -	Isle of Anglesey.
† Houghton-le-Spring - -	Durham.
Hunstanton - - - -	Norfolk.
Kidsgrove - - - -	Staffordshire.
Kirkby Stephen - - -	Westmoreland.
Kirkheaton (Dalton and Lepton) -	Yorkshire.
† Knottingley - - - -	Yorkshire.
‡ Leeds New Gas Company - -	Yorkshire.
Leighton-Buzzard - - -	Bedfordshire.
Lepton (Kirkheaton and Dalton) -	Yorkshire.
Llanfyllin - - - -	Montgomeryshire.
Llangefni - - - -	Isle of Anglesey.

Heywood, Higginbottom & Co., Messrs., Paper Mills, Stockport, Cheshire.
Heap, Brothers, Messrs., Crossland Moor, Huddersfield, Yorkshire.
Horrocks & Norris, Messrs., Print Works, Hayfield, Cheshire.
Hughes & Sons, Chapel-en-le-Frith, Derbyshire.
Holdsworth & Co., Messrs., near Dewsbury, Yorkshire.
Harper & Moore, Messrs., Fire-brick Works, Stourbridge, Worcestershire.

Inman, W., Esq., Harefield House, near Birkenhead, Cheshire.
Inman, C., Esq., Upton, near Birkenhead, Cheshire.

Joicey, Major, Newton Hall, near Stocksfield, Northumberland.
Jones, F. R., Esq., Lane Ends, near Huddersfield, Yorkshire.
Japanese Government Mint, Japan.
Japanese Government Railways, Japan.
Jebson, Messrs. T. & Son, Skelmanthorpe, near Huddersfield, Yorkshire.

Knightley, Sir R., Bart., M.P., Fawsley Park, Daventry, Northamptonshire.
Kurtz, A. G., Esq., Sutton Alkali Works, St. Helen's, Lancashire.
Kramsta & Sons, Messrs., Bolkahein, Silesia, Germany.
Keadby Station, South Yorkshire Railway, Lincolnshire.
Kraussa & Co., Messrs., St. Petersburg, Russia.

Lloyd, Lieut.-Colonel, Lillesden, Hawkhurst, Kent.
Lyon, F., Esq., Mollington Hall, near Chester, Cheshire.
Lund, J., Esq., Park Hills, near Bradford, Yorkshire.
Linoleum Manufacturing Company (Limited), Staines, Middlesex.
Lippolt, A., Esq., Chemnitz, Saxony, Germany.
Lomax, R. H., Esq., Coldham Hall, Bury St. Edmund's, Suffolk.
Lodge, Messrs. George & Sons, Fenay Mills, near Huddersfield, Yorkshire.
Lee & Bolton, Messrs., Hyde Iron Works, near Stourbridge, Worcestershire.
Landless, Brothers, Messrs., Nelson, near Burnley, Lancashire.

Mackaness, J., Esq., Wootton Bassett, Wiltshire.
Mackenzie, E., Esq., Fawley Court, Henley-on-Thames, Oxon.
Mackenzie, E., Esq., Downham Hall, near Brandon, Suffolk.
Mather, C., Esq., Horncliffe Hall, near Berwick-on-Tweed, Northumberland.
Müller, H. C., Herr, Hirschfelde, Saxony, Germany.
Morales, Messrs. J. M., & Co., Matanza, Havannah, Cuba.
Miller, Thomas, Esq., Redlands, Bristol, Somersetshire.

Naylor, John, Esq., Leighton Hall, near Welshpool, Montgomeryshire.

Powell, W., Esq., M.P., Dantesey House, Chippenham, Wiltshire.
Pound, Rev. L., Appeldeercomb Court, Isle of Wight.
Pedder, E., Esq., Preston, Lancashire.
Patent Nut and Bolt Company (Limited), Cwm Brân, South Wales.
Pearson, John, Esq., Goldborne Park, near Liverpool, Lancashire.
Pattison, Hugh Lee, Esq., Scots House, nr. Newcastle-on-Tyne, Northumberland.
Pickering, Mr. Thomas, Driffield, Yorkshire.

Huddersfield and London.

RYLAND, Brothers, Messrs., Wire Mills, near Warrington, Lancashire.
Robinson, James & Co., Messrs., Honley, near Huddersfield, Yorkshire.
Radford & Son, Messrs., near Matlock, Derbyshire.
Riddell, Messrs. W. & Co., Paper Mills, Hurstbourne, Hampshire.
Robinson & Taylor, Messrs., Rastrick, near Huddersfield, Yorkshire.
Robinson, R. R., Esq., Henley Park, Henley-on-Thames, Oxon.
Robinson, D., Esq., Bold Venture Lime Works, Chatburn, Lancashire.
Ramsbottom, J. H., Esq., M.D., Huddersfield, Yorkshire.
Rhodes, Mr. J. A., Mirfield, Yorkshire.

SHORTRIDGE, R., Esq., Cleadon Meadows, near Sunderland, Durham.
Stephenson, P., Esq., Neston, near Birkenhead, Cheshire.
Sutton, W., Esq., Scotby, near Carlisle, Cumberland.
Sharp, Captain, near Birkenhead, Cheshire.
Slack, John, Esq., Paper Mills, Hayfield, Cheshire.
Siam, H.M. The King of, Palace, Siam.
Smedley, J., Esq., Lee Mills, Matlock, Derbyshire.
Swinbourne, E., Esq., near Newcastle-on-Tyne, Northumberland.
Simmons & Co., Messrs., Paper Mills, near Nottingham, Notts.
Smith, Ely, & Co., Messrs., Woollen Mills, Greetland, near Huddersfield, Yorks.
Syddall and Co., Messrs., near Stockport, Cheshire.
Solomon, M. B., Esq., Albemarle Street, London.
Spiegelberg & Co., Messrs., Vechelde, near Brunswick, Germany.
Stanton Iron Company, Iron Works, near Nottingham, Notts.
Skinner & Holford, Messrs., Waleswood Colliery, near Sheffield, Yorkshire.

TANNETT, WALKER & Co., Messrs., Leeds, Yorkshire.
Thompson, Palmer & Co., Messrs., Norwich, Norfolk.
Taylor, Brothers, Messrs., Almondbury, near Huddersfield, Yorkshire.

VANSITTART, G. H., Esq., Bisham Abbey, Marlow, Buckinghamshire.
Viles, Edward, Esq., Codsall, Wolverhampton, Staffordshire.

WYNN, SIR WATKIN WM., Bart., M.P., Wynnstay, Ruabon, Denbighshire.
Websky, Herr Julian, Tannhausen, Silesia, Germany.
Wheatley, H., Esq., Mirfield, Yorkshire.
Wilkinson, H., Esq., Thornton, Skipton, Yorkshire.
Wilkinson, E. & Co., Messrs., Broad Carr and Elland, near Huddersfield, Yorks.
Walker, Parker & Co., Messrs., Lead Works, Chester, Cheshire.
Wheatcroft & Son, Messrs., Belper, Derbyshire.
Waites & Co., Messrs., Clayton West, near Huddersfield, Yorkshire.
Waller & Lockwood, Messrs., Brighouse, near Huddersfield, Yorkshire.
Wood, Mr. John, Huddersfield, Yorkshire.

ZIMMERMAN, Herr J., Hotel, Zittau, Germany.

PRINTED BY THEW AND SON, KING'S LYNN.